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a record of research

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HUMAN BIOLOGY

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Vol. II No. 1

HUMAN BIOLOGY

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FEBRUARY, 1930

A QUANTITATIVE STUDY IN HUMAN TERATOLOGY

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The quantitative study of normal human development is an established procedure based upon a large amount of precise data and a number of well-tested methods. But the application of the quantitative method to the abnormal development and growth of the human body is still in its initial stages. Numerical data on the subject are still relatively few and the necessary analytic techniques are far from complete. The purpose of this paper is to present a quantitative method for the numerical and graphic analysis of abnormal human development as illustrated by its application to two widely diverse forms of human monstrosity.[1]

MATERIAL

Two specimens were used in this analysis—one simple and one double monster.

The external appearance of the simple monster is shown in figures 1 and 2. The specimen was a male. The head and upper extremities appeared relatively large while the pelvis and lower extremities seemed relatively small. The arms were distinctly larger and longer than the lower extremities—the reverse of the usual relationship in normal older fetuses or newborn infants. A peculiar malformation was present on either side at the knee, where a web or flap of skin extended from the posterior aspect of the thigh to the calf. The

[1] A study from this laboratory by J. C. Nañagas ('25) on the development of the anencephalic fetus included a part of these methods.

internal organs also showed marked abnormalities, which will be described in another publication. The body weight was 1,527 gm., and the total or crown-heel length was 34.8 cm.

FIG. 1. An anterior view of the simple monster.

FIG. 2. An inferior view of the simple monster illustrating the webbing of the lower extremities.

FIG. 3. A view of the more completely formed "anterior" surface of the double monster.

FIG. 4. A view of the secondary, incompletely formed, "anterior" surface of the double monster.

The external appearance of the double monster (female) is shown in figures 3 and 4. It was a typical example of "Janus" or Cephalothoracopagus monosymmetros. The body was fused anteriorly from

crown to umbilicus and had two fused umbilical cords. A single complete face was present on one side of the fused heads. The other side presented an incomplete face with a slight oral depression and a single eye, closed by a rudimentary lid (figure 27). The body weight was 1,160.6 gm., and the total or crown-heel length was 30.7 cm.

The majority of the measurements proposed by Scammon and Calkins ('29) were made on the simple monster and fifty-seven were used in the present study.[2] All of the measurements proposed by Scammon and Calkins were made upon the double monster, except the occipito-frontal circumference and diameter, and the menton-lambda circumference, which cannot be determined for this type of monstrosity.

The linear dimensions were measured with steel calipers. The larger circumferences were measured with a steel tape. Circumferences of the upper and lower extremities were measured by encircling the limb three times with a moderately coarse linen thread. The thread was cut at the point of termination of the third circumference, measured with a steel tape and the total length divided by three.

The complete set of measurements of the double monster was taken on three different days and the means of these three sets were used in subsequent calculations. In the determination of bilateral parts each dimension was measured five times and the average used. Means based upon repeated measurements showed little change from the original or first determination.

TREATMENT OF DATA

The measurements of these specimens were first compared with those of presumably normal ones by the following method. A series of dimensions that seemed, by inspection, to be abnormal in size were first selected. Corresponding measurements of normal fetuses ranging between 30 and 32 cm. in crown-heel length were tabulated from observations made in this laboratory on 10 supposedly normal specimens. Corresponding measurements of 10 fetuses between 34 and 36 cm. were also collected. These ranges included normal

[2] The following measurements were omitted: Spine length, occipito-frontal circumference, occipito-frontal diameter, menton-lambda circumference, menton-bregmatic diameter, auriculo-vertex diameter, bideltoid circumference, xiphisternal circumference, anteroposterior diameter at xiphisternal junction, thigh length (posterior iliac spine to lateral condyle of femur), pelvic height, external conjugate diameter and bituberous diameter.

specimens with crown-heel lengths falling within 1 cm., plus or minus, of the length of the simple or double monster, respectively. The means, standard deviations, and probable errors of the distributions of these measurements were then computed. Comparison of the observed weight of the simple monster with the weights of normas fetuses between 34 and 36 cm. in body length was made on the basir of a semi-interquartile range of an array of 80 specimens. A similar test[3] was made of the weight of the compound monster on the basis of 49 specimens. The computations for the double monster were made from the average measurement in each case as the component parts approximated one another very closely.

A ratio was established by dividing the departure of the observed measurement from the corresponding mean "normal" value by the probable error of the distribution for each dimension (tables 7 and 8).

Graphic presentations of certain data on tables 7 and 8 are shown in figures 35 and 36. The value of each "normal" case for each dimension (ordinate) considered was plottted against the corresponding crown-heel length (abscissa). The observed measurement was then plotted and a line drawn in each panel representing the "normal" mean value. Lines representing two and three times the probable error of the distribution were drawn in each panel above and below the mean value. These graphs show the degree of departure of the observed dimension from the distribution of the "normal" cases. They also indicate the degree of significance of the supposed abnormality of the observed dimension. When an observed measurement falls outside the limits of two times the probable error, the chances of its occurrence in a normal distribution are about one in five, and when it falls outside the limits of three times the probable error the chances are somewhat less than one in twenty. The writer has regarded any dimensions falling outside the limits of three times the probable error as significant.

A second and more comprehensive method used in the analysis is based upon the comparison of the dimensions of the abnormal specimens with norms established by analytic methods. Norms of this type for the dimensions of the body in the fetal period have been developed by a number of investigators including Mall ('07), Calkins

[3] As the mean and median values for both the single and double monsters approximate one another closely, and as the observed values fall far outside the limits of the semi-interquartile range, this analysis has been considered sufficiently accurate.

('21, '22), Scammon ('21), Dunn ('21), Noback ('22), Calkins and Scammon ('25), Scammon and Calkins, and Akiba ('24).

Body length may be computed from any chosen dimension by the use of these empirical formulae. From this dimension the remaining external body measurements that are "normal" for the computed body length may be calculated. These values may then be compared with the values of the dimensions of the fetus studied.

For example, the body length of a fetus that seems to be abnormal may be measured and the remaining "normal" dimensions of a fetus are computed in terms of this value. The two sets of values—the "normal" and the observed—thus established may be examined for any marked discrepancies between them. Furthermore, if there *be* any markedly variable dimension another body length may be computed from *it*, and the remaining "normal" dimensions of a fetus may then be computed in terms of the latter body length. The values of the dimensions of the latter fetus may be compared with the values of the "normal" and observed fetuses as a means of more detailed analysis. Thus it is possible to compare any external dimension with any other external body dimension and measure the relationship between them.[4]

The analysis of these data was based primarily upon empirical formulae for the proportionate growth of the human fetus given by Calkins and Scammon. These formulae are all computed to the total body length and it was necessary to develop substitution formulae. The simple algebra of this computation is described in detail by Noback, Nañagas ('25), and Scammon and Calkins.

A further analysis was made by the calculation of the crown-heel length of a fetus representative of the observed body weight. This was done on the basis of the weight-length formula of Scammon and Calkins ('24). The remaining measurements of this fetus were then computed from this calculated length. These calculated values, with the computed deviations as observed in this abnormal specimen, are shown in tables 1 and 2. The material obtained by these methods is so extensive that only a few of the more significant figures will be presented here.

The external dimensions of the observed fetus were plotted on coördinate paper and a body outline constructed from them. Measure-

[4] Effects of variability, goodness of fit, grouping, etc., on these relationships, are discussed at some length in the paper of Scammon and Calkins ('29).

ments of a so-called "normal" fetus were computed from the observed crown-heel length with empirical formulae and plotted in the same manner as the observed dimensions for purposes of comparison. Constructions were also made of fetuses computed from the observed vertical head height, the length of the upper extremity, upper arm, forearm, hand, lower extremity, thigh, leg, distance from suprasternal notch to pubis, distance from suprasternal notch to xiphisternal junction, and body weight.

TABLE 1

Comparison of Selected External Measurements of Simple Monster with those of "Normal" and Computed Fetuses

DIMENSION USED	MEASUREMENT AS OBSERVED (*cm.*)	MEASUREMENT AS COMPUTED FROM OBSERVED CH LENGTH (*cm.*)	MEASUREMENT COMPUTED FROM CH LENGTH AS CALCULATED FROM:				
			VHH (*cm.*)	UEL (*cm.*)	LEL (*cm.*)	SN-Xs (*cm.*)	Weight (*cm.*)
CH	34.88	34.88	46.36	39.50	37.06	29.02	40.04
BiP	8.73	6.34	8.79	7.55	7.10	5.68	7.75
VHH	10.85	8.32	10.84	9.34	8.80	7.32	9.59
SN-Xs	3.06	3.72	5.01	4.24	3.97	3.09	4.41
SN-Pub	9.85	9.78	12.91	11.04	10.38	8.21	11.39
TDNip	8.96	7.15	9.51	8.09	7.59	5.97	8.33
UEL	15.46	13.58	18.16	15.42	14.44	11.26	15.87
UAD	2.73	1.91	2.62	2.35	2.29	1.56	2.26
LEL	15.18	14.24	19.16	16.22	15.21	11.75	16.72
TD	2.57	3.00	4.16	3.48	3.24	2.45	3.59

Weight 1,527 gm.

A series of superimpositions of the outlines of computed fetuses upon those of the observed fetus were made to show the principal regions of digression in growth of the observed fetus. These superimpositions were also made upon the computed "normal" fetal outline.

In the analysis of the simple monster the upper and lower extremities were considered first, for they seemed to be the regions of most marked abnormality. A more detailed analysis was then made of each longitudinal segment of the extremities to determine whether the components of the limb had developed in normal proportions.

The same general method was used in the analysis of the double monster. Comparisons were made between right and left components

TABLE 2

Differences in Per Cent between Measurements of Observed Simple Monster and "Normal" and Computed Fetuses

DIMENSION USED	DIFFERENCES IN PER CENT OF COMPUTED MEASUREMENTS FROM THOSE OF OBSERVED AND CALCULATED "NORMAL" FETUSES FOR:					
	VHH	UEL	LEL	SN-Xs	Weight	
CH						observed
	−32.9	−13.0	− 6.2	+20.1	−14.2	calculated
BiP	− 0.6	+15.6	+22.9	+53.7	+12.0	observed
	−38.6	−19.0	−11.9	+ 1.6	−18.2	calculated
VHH	+ 0.1	+16.1	+23.3	+48.2	+13.0	observed
	−30.2	−12.3	− 5.7	+13.6	−13.3	calculated
SN-Xs	−63.7	−38.5	−29.7	− 0.9	−17.1	observed
	−34.5	−13.9	− 6.7	+20.3	−15.7	calculated
SN-Pub	−31.0	−12.0	− 5.3	+19.9	−13.3	observed
	−32.0	−12.8	− 3.7	+19.1	−14.2	calculated
TDNip	− 6.1	+10.7	+18.0	+50.8	+ 7.0	observed
	−33.0	−13.1	− 6.1	+20.3	−14.2	calculated
UEL	−17.4	+ 0.2	+ 7.0	+37.3	− 3.9	observed
	−33.7	−13.5	− 6.3	+20.6	−14.4	calculated
UAD	+ 4.1	+16.1	+19.2	+15.0	+ 2.0	observed
	−37.1	−23.0	−19.9	+22.5	−15.5	calculated
LEL	−26.2	− 6.8	+ 0.2	+29.1	−20.0	observed
	−34.5	−13.7	− 6.8	+21.1	−14.9	calculated
TD	−61.8	−35.4	−26.0	+ 4.8	−28.5	observed
	−38.6	−16.0	−10.5	+22.4	−16.5	calculated

of the monster in so far as duplicate[5] parts would permit. This comparison furnished a fairly accurate measure of the degree of duplication of the components forming the monster.

[5] The word "duplicate" is used in this paper in the sense of " the same identical part" of each component of the monster. For example; the upper extremities of each component are considered as "duplicate" parts.

Further analysis was made as for the simple monster. Measurements of a "normal" fetus for the total body length of the monster were computed and dimensions plotted. Outlines were constructed of fetuses computed from the total head circumference, one-half the total head circumference, the total body weight, one-half the total body weight, the distance from suprasternal notch to umbilicus, and the vertical head height. Comparisons were made between the regions of the monster and the computed "normal" and the observed fetuses. These comparisons were made graphically by superimposition as for the simple monster. When one fetus was computed as the equivalent of the entire monster (two fused[6] fetuses), the superimpositions were against *two* "normal" fetuses.

As the development of the facial areas on each side of the fused heads was not equal, a comparison was made of these regions. The outline areas of each facial region were plotted by the method of Scammon ('21). Each area was transferred to 'Kodaloid' film, cut out and weighed, and the area determined therefrom by the technique of Scammon and Scott ('27). The facial area weights were taken three times and their mean values are given in table 6. Superimpositions were made of the actual areas of each face, and each against *two* "normals." One aspect of the facial region was superimposed upon a normal facial outline constructed to an area equivalent to the observed facial region. This outline was then plotted against another outline equivalent in area to that of two "normals." "Normal" outlines were also compared with areas equivalent to one-half and eleven-twentieths that of the facial region, the latter comparison illustrating the reverse ratio.

DISCUSSION OF FINDINGS

The Simple Monster

a. General comparisons

Certain generalizations may be drawn from the comparison of the observed fetus and a "normal" fetus, as computed from the crown-heel length (tables 1 and 2). According to this criterion, there is an overgrowth of all dimensions of the head, of the diametric dimensions

[6] The word "fused" or "fusion" are used in this discussion in a purely descriptive sense, rather than as accurate mechanical terms. They do not imply the joining of two embryos during development.

of the trunk, and of the axial and diametric dimensions of the upper extremities of the specimen under investigation. However, measurements of the vertical or cranio-caudal trunk dimensions indicate that the body has failed to grow in length in proportion to these parts and the lower extremities show retardation in diametric growth. This comparison is shown graphically in figure 5. The computations also show that the general total body lengths, *computed from various observed dimensions*, exceed the observed and calculated "normal" body length of the specimen, except in the case of body length derived from the observed distance from suprasternal notch to xiphisternal junction.

b. Comparisons of the upper extremity

A more detailed analysis of the upper extremity is desirable, for this appears to be a region of marked change in growth. Tables 1 and 2 give a comparison of the measurements computed from the *observed upper extremity length* with those of the observed fetus, and with the several sets of calculated measurements. This comparison is illustrated by figure 6, which gives a graphic comparison of the observed fetus with a fetus computed from the observed length of the upper extremity.

On the basis of this criterion the observed body length appears much reduced. The head is high, wide and long, and the neck has a large circumference. The circumference, transverse and anteroposterior diameters of the chest are definitely enlarged. The vertical trunk dimensions are generally shortened. The diameters of the segments of the observed upper extremities are definitely enlarged. The dimensions of the observed lower extremities are definitely shortened, and the diameters and circumferences are reduced. In general, this comparison indicates that the upper extremity of the observed fetus has undergone a marked overgrowth.

A comparison of the fetus *computed from the observed upper extremity length* with the "normal" fetus *computed from the observed body length* (figure 7) may be used to test these conclusions. The "normal" fetus shows a vertical head height less than that of the fetus computed from the observed upper extremity length, and a reduction in transverse and anteroposterior head diameters. The neck circumference is only slightly smaller. The chest is reduced in circumference, transverse and anteroposterior diameters, and all of the linear trunk dimensions are smaller. All of the measurements of the "normal"

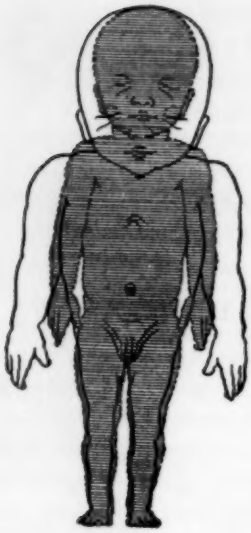

Fig. 5

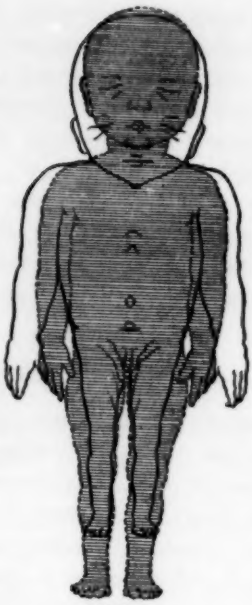

Fig. 6

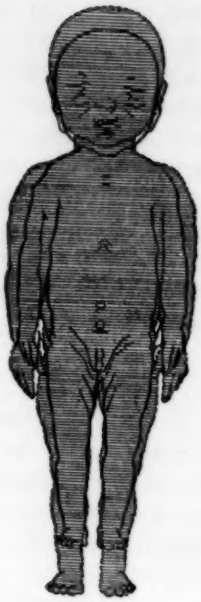

Fig. 7

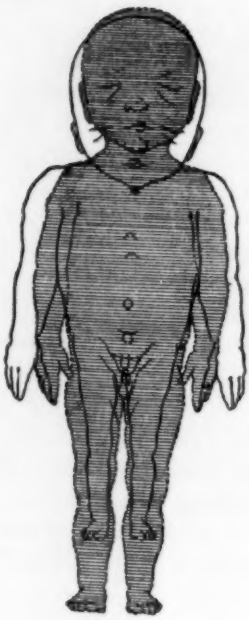

Fig. 8

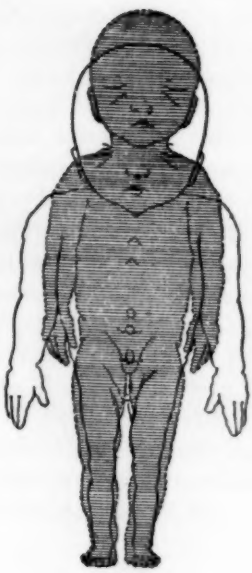

Fig. 9

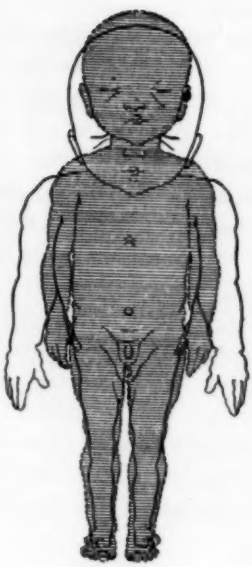

Fig. 10

upper and lower extremities are definitely smaller. These findings seem to substantiate the conclusions regarding probable overgrowth of the upper extremity of the observed fetus.

This comparison of the computed fetus with the so-called "normal" fetus has been made in detail to illustrate the use of this method. The method has been applied to each dimension measured, but only a few representative examples are included in this account.

c. Comparisons of the upper arm

A further check upon the conclusions drawn from the analysis of the upper extremity as a whole was made by analyzing one of its major segments—the upper arm (figure 8).

A comparison of the measurements *computed from the observed upper arm length* with the observed fetus shows that the body length of the latter is reduced. The observed head and neck measurements and chest measurements are increased. The vertical trunk measurements are smaller, and the length of the upper extremity as a whole is slightly shortened, but its circumferences are increased. The lower extremity is definitely shortened and reduced in circumference.

FIG. 5. A superimposition of the outline of the "normal" fetus, computed by empirical formulae from the observed body length, upon the observed outline of the simple monster. The outlines are oriented to total body length. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 6. A graphic comparison made by superimposing the outline of the simple monster upon that of a fetus computed by empirical formulae from the observed upper extremity length of the monster. The outlines are oriented to upper extremity length from the acromion. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 7. A graphic comparison made by superimposing the outline of a "normal" fetus, computed by empirical formulae from the observed body length of the simple monster, upon that of a fetus computed by empirical formulae from the observed upper extremity length. The outlines are oriented to upper extremity length from the acromion. (The computed fetus is shaded and drawn in broken line and the "normal" fetus is drawn in solid line.)

FIG. 8. A graphic comparison made by superimposing the observed outline of the simple monster upon that of a fetus computed by empirical formulae from the observed upper arm length. The outlines are oriented to upper arm length from the acromion. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 9. A graphic comparison made by superimposing the observed outline of the simple monster upon that of a fetus computed by empirical formulae from the observed lower extremity length. The outlines are oriented to lower extremity length from the greater trochanter. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 10. A graphic comparison made by superimposing the observed outline of the simple monster upon that of a fetus computed by empirical formulae from the observed thigh length. The outlines are oriented to thigh length from the greater trochanter. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

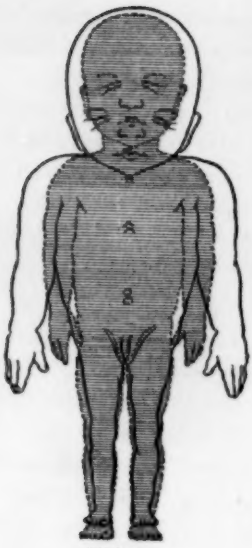

Fig. 11

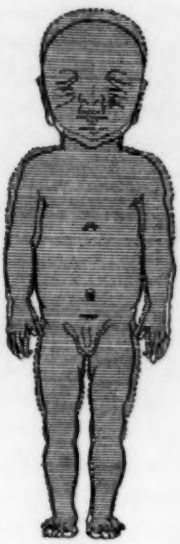

Fig. 12

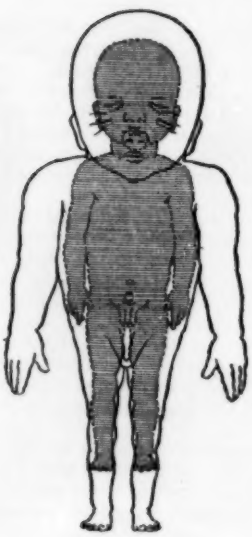

Fig. 13

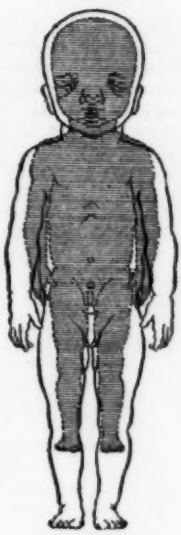

Fig. 14

Comparison of the fetus *computed from the observed crown-heel length* with the fetus *computed from the observed upper arm length* supports these conclusions, although these computations are not included in the present paper.

d. Comparisons of the lower extremity

The same type of analysis indicates that the lower extremities of the observed fetus are underdeveloped. Graphic comparison of the observed fetus with a fetus *computed from the observed lower extremity length*, (figure 9) shows that the observed body length is apparently reduced. All the dimensions of the head, neck and chest are enlarged. The vertical trunk dimensions are reduced throughout. The upper extremity is increased in length and circumferences, and all of the dimensions of the lower extremity are reduced.

e. Comparisons of the thigh length

A segment of the lower extremity was next analyzed as a further check on the conclusions drawn from the analysis of the lower extremity as a whole (figure 10). A comparison of the observed fetus with a fetus *computed from the observed thigh length* shows that the body length of the observed fetus is reduced. All dimensions of the head, neck and chest and upper extremities of the observed fetus are enlarged. The vertical trunk dimensions are reduced throughout. The lower extremities are only slightly reduced in length and in diameter.

FIG. 11. A graphic comparison made by superimposing the observed outline of the simple monster upon that of a fetus computed by empirical formulae from the observed distance from the suprasternal notch to the pubis. The outlines are oriented to the distance from the suprasternal notch to the pubis. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 12. A graphic comparison made by superimposing the outline of a "normal" fetus, computed by empirical formulae from the observed body length of the simple monster, upon that of a fetus computed by empirical formulae from the observed distance from the suprasternal notch to the pubis. The outlines are oriented to the distance from the suprasternal notch to the pubis. (The computed fetus is shaded and drawn in broken line and the "normal" fetus is drawn in solid line.)

FIG. 13. A graphic comparison made by superimposing the observed outline of the simple monster upon that of a fetus computed by empirical formulae from the observed distance from the suprasternal notch to the xiphisternal junction of the simple monster. The outlines are oriented to the distance from the suprasternal notch to the xiphisternal junction. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 14. A graphic comparison made by superimposing the outline of a "normal" fetus, computed by empirical formulae from the observed body length of the simple monster, upon that of a fetus computed by empirical formulae from the observed distance from the suprasternal notch to the xiphisternal junction. The outlines are oriented to the distance from the suprasternal notch to the xiphisternal junction. (The computed fetus is shaded and drawn in broken line and the "normal" fetus is drawn in solid line.)

The thigh has approached the normal more nearly than any segment thus far analyzed. However, the discrepancy in body lengths leads one to suspect the existence of a region of marked growth deviation not yet analyzed.

f. Comparisons of the distance from suprasternal notch to pubis

The preceding comparisons are quite consistent in their indication of a reduction of the longitudinal dimensions of the observed fetus, but the comparisons of the extremities do not show that the loci of deviation in growth lie in them. Therefore, a detailed study of the vertical trunk dimensions is necessary.

A comparison was made of the observed fetus with a fetus *computed from the observed distance from suprasternal notch to pubis* (figure 11). In this instance there is only a slight discrepancy in relative body lengths, when compared with those observed in the preceding analyses. This suggests that this region probably contains the chief locus of disturbance in growth. All dimensions of the upper extremity are enlarged, while the lower extremities are only slightly reduced. Thus the growth of the lower extremities tends to follow the growth of the region between the suprasternal notch and the pubis.

Comparison of the fetus *computed from the distance from suprasternal notch to pubis* with the "normal" fetus supports the preceding observations and again shows the application of this supplementary type of analysis (figure 12). In this case the differences in all dimensions are relatively slight when compared with those noted in the preceding comparisons.

It may be concluded from these observations that the development of the *caudal* portion of the body corresponds to the "normal" fetus computed from the observed body length and that the *cranial* portions of the body have progressed at a much different rate of growth. A more detailed analysis of the individual longitudinal trunk measurements is desirable in order to determine the region of most marked deviation in growth that may account for the apparent discrepancies in growth of the cranial and caudal parts of the fetus.

g. Comparisons of the distance from suprasternal notch to xiphisternal junction

Comparison of the observed fetus with a fetus *computed from the distance from suprasternal notch to xiphisternal junction* confirms the previous conclusions (figure 13). The observed body length is defi-

nitely increased and all other external dimensions are definitely enlarged. As a check on this observation the fetus *computed from the observed distance from suprasternal notch to xiphisternal junction* was compared with the "normal" fetus (figure 14). In this case all dimensions of the computed fetus are reduced.

The preceding analysis has shown the relative effect of the deviations in the proportions of a number of body segments on the resulting form of the body upon the whole. It also indicates that there is a region of probable greatest divergence from the normal lying between the suprasternal notch and the xiphisternal junction.

h. Comparisons of weight

In order to compare the growth of the observed fetus, as a whole, to the "normal," a fetus was computed from the observed weight according to the formulae previously cited (figure 16). In this case the observed head and neck measurements are definitely enlarged, but not to the marked degree as in the preceding comparisons. The chest measurements are only slightly increased, and the upper extremities are nearly equal. The vertical trunk measurements and the lower extremities are definitely shortened.

A comparison of the fetus computed from the observed body weight with the "normal" fetus shows a reduced observed body length. Thus it indicates that the body weight is representative of a fetus of much larger measurements than those of the fetus computed from the observed body length. This supports the previous conclusion that there has been an area of growth depression in some of the vertical segments of the trunk.

i. Summary and discussion

It was impossible to estimate the normal proportions of this fetus with respect to age, for no clinical data are available regarding the age of the specimen. It may be that the cephalic portion of the fetus is hyperdeveloped and that the caudal regions of the body are hypodeveloped through the inhibitory influence of the more rapidly growing cranial region. But it is also possible that the cephalic region has developed at a normal rate and the growth of the caudal region has been inhibited.

The cranial and caudal regions have grown at different rates. The dimensions of the head and upper extremities seem relatively large, and the pelvis and lower extremities seem relatively small. Therefore, a

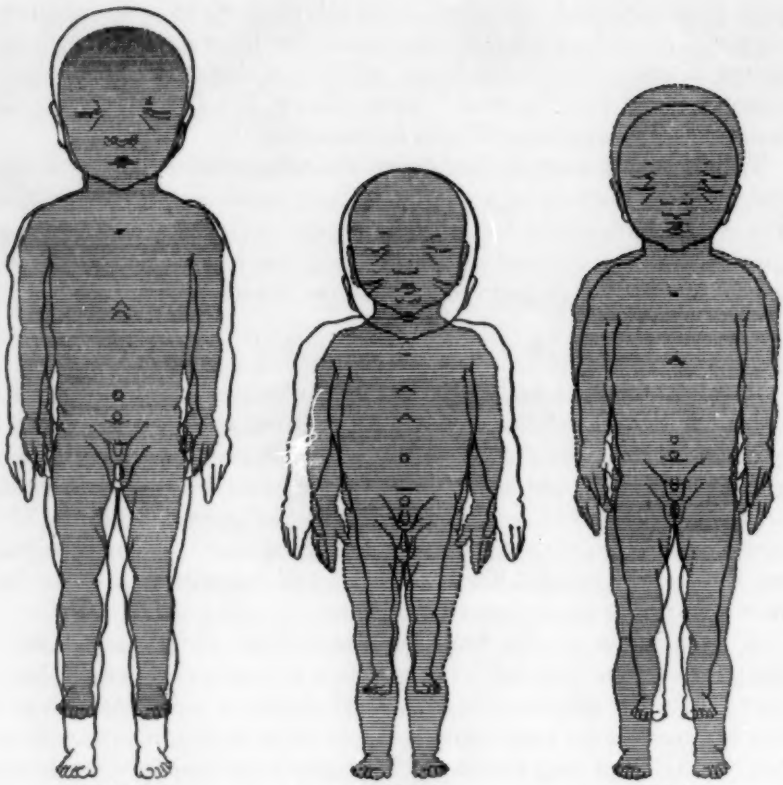

FIG. 15. A graphic comparison made by superimposing the outline of a fetus, computed by empirical formulae from the observed vertical head height, upon that of a fetus computed by empirical formulae from an "average" of the calculated body lengths derived from the observed vertical head height and lower extremity length of the simple monster. The outlines are oriented to vertical head height from the menton. (The "average" fetus is shaded and drawn in broken line and the fetus computed from the observed vertical head height is drawn in solid line.)

FIG. 16. A graphic comparison made by superimposing the observed outline of the monster upon that of a fetus computed by empirical formulae from the observed weight. The outlines are oriented to total body length from the crown. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 17. A graphic comparison made by superimposing the outline of a fetus, computed by empirical formulae from the observed lower extremity length of the simple monster, upon that of a fetus computed by empirical formulae from an "average" of body lengths derived from the observed vertical head height and lower extremity length of the simple monster. The outlines are oriented to lower extremity length from the greater trochanter. (The "average" fetus is shaded and drawn in broken line and the fetus computed from the observed lower extremity length is drawn in solid line.)

fetus was constructed according to a body length equal to the *average* of the body lengths computed from the vertical head height and from the lower extremity length. This "*average*" fetus was then superimposed upon the fetus constructed from the observed vertical head height and upon the fetus constructed from the observed lower extremity length (figures 15 and 17, respectively).

These comparisons show that the fetus constructed from the lower extremity length does not agree closely with the "average" fetus, and the fetus constructed from the vertical head height is larger than the "average" fetus in most dimensions.

The ratio which the observed distance from the suprasternal notch to the xiphisternal junction forms of the distance from the suprasternal notch to pubis appears to be reduced when compared

TABLE 3

Comparision of Ratios of Segments to Complete Members for the Observed and "Normal" Fetuses in the Study of the Simple Monster

SEGMENT OF DIMENSION UEL	RATIO		SEGMENT OF DIMENSION LEL	RATIO		SEGMENT OF DIMENSION VHH	RATIO	
	OBSERVED FETUS	NORMAL FETUS		OBSERVED FETUS	NORMAL FETUS		OBSERVED FETUS	NORMAL FETUS
UAL	0.40	0.40	Tro-Kn	0.45	0.45	BiP	0.83	0.77
FAL	0.31	0.31	Kn-Mal	0.48	0.48	NM	0.45	0.45
HL	0.29	0.29	FL	0.34	0.34	AVH	0.83	0.83

SEGMENT OF DIMENSION SOFD	RATIO		SEGMENT OF DIMENSION SN-Pub	RATIO	
	Observed fetus	Normal fetus		Observed fetus	Normal fetus
OMC	3.33	3.33	SN-Xs	0.31	0.38
SOBC	3.33	3.33	Xs-Pub	0.77	0.77
SOBD	1.00	1.00	Xs-U	0.59	0.53
SOFC	3.33	3.33	SN-U	0.91	0.91

with the ratio for the "normal" fetus (table 3). But the ratios of the other trunk segments to the trunk as a whole coincide with the theoretical ratios as do the segments of the upper and lower extremities and the head dimensions considered.

The results of this study may be examined in the light of Child's ('24, '25) concept of an axial metabolic or growth gradient, first demonstrated on invertebrate but later applied to vertebrate development. Child has shown that the "growth gradient" is closely associated with the "law" of developmental direction, but that there are always certain regions which dominate over others and control their rates of growth. This dominance is progressive and passes from one region to another in a cephalocaudal direction. However, it is possible for progression to cease at any point and for the existing growth gradient to be obliterated. Furthermore, a secondary region of physiologic or metabolic dominance with a new gradient system may be established. Nañagas found that growth changes in the anencephalic monster fall in line with this scheme.

If one applies this concept to the present case it may be reasoned that a secondary center of growth control has been established and this has dominated the growth of the regions caudal to it. The previous conclusions, that the cranial regions of the fetus (the head and upper

TABLE 4

Comparison of Measurements of Both Components of Double Monster with "Normal" and Computed Fetuses

DIMENSION USED	MEASUREMENT AS OBSERVED		RIGHT AND LEFT COMPONENT MEASUREMENTS COMPUTED FROM OBSERVED CH LENGTH (*cm.*)	MEASUREMENT COMPUTED FROM CH LENGTH AS CALCULATED FROM:					
	Right (*cm.*)	Left (*cm.*)		VHH (*cm.*)	THC (*cm.*)	0.5 THC (*cm.*)	TBW (*cm.*)	0.5 TBW (*cm.*)	SN-U (*cm.*)
CH	30.7	30.7	30.7	34.1	41.9	19.7	37.2	27.1	29.6
CU	15.8	15.8	16.6	18.3	22.4	10.9	19.7	14.5	16.0
BiP	6.2	6.3	5.9	6.6	8.0	3.9	7.2	5.3	5.8
VHH	7.7	....	7.7	8.5	10.3	5.2	9.2	6.9	7.5
U-Pub	3.6	3.6	2.3	2.7	3.6	1.0	3.0	1.9	2.2
Nip-Nip	6.7	6.6	3.9	4.3	5.3	2.5	4.7	3.4	3.8
TD-10-R	5.0	5.0	6.4	7.1	8.8	3.9	7.8	5.6	6.1
UEL	13.2	13.3	11.9	13.3	16.4	7.5	14.5	10.5	11.5
LEL	12.6	12.5	12.5	13.9	17.3	7.7	15.3	10.9	12.0

extremities) have developed as groups at a certain rate of growth and that the caudal regions of the body (the trunk and lower extermities) have developed as groups but at another rate of growth, support this view. This secondary growth center seems to lie between the suprasternal notch and the xiphisternal junction.

Nañagas showed that anencephalic fetuses develop according to the general scheme postulated by the "law" of developmental direction. In these fetuses the upper extremities were hyperdeveloped. However, the segments of the upper extremity were not, as in this specimen, in a normal ratio to the complete member (table 3).

In an experimental study of single deformities and double monsters Stockard ('21) concludes that *slowing* does not eliminate normal equalities in rate of developmental change of the parts and that on resumption of a faster rate proper balance is "assured." Nañagas has shown that in the anencephalic fetus, which is probably a result of disturbance of the developmental rate at an early period, the segments of the rapidly growing upper extremities are not in proper balance.

Furthermore, in the analysis of this simple monster it is apparent that a "proper balance" has not been "assured" with reference to the longitudinal trunk segments. Therefore, according to Stockard, the rates of growth could hardly have been merely *slowed*.

Stockard states, further, that a *complete* cessation of development reduces the rate of growth of all parts to zero, and that, on resumption of development, all portions start to grow at about the same rate. But in the present case there has been a marked difference in rate of growth of the cephalic region as compared with the caudal region. Consequently, if the developmental rate of the fetus had been reduced to zero, this resultant form could not have been produced.

Stockard suggests that any deformity recorded in the literature, with certain exceptions not relevant to this discussion, may be explained on either of the preceding bases. Analysis of this fetus however fails to coincide with either. The writer thinks that the establishment of primary and secondary centers of growth control is a more acceptable explanation of this type of single monster.

The Double Monster

a. General comparisons

The similarity of duplicate parts of the two components of the compound monster is shown by their measurements (tables 4 and 5).

TABLE 5

Differences in Per Cent between Measurements of Both Components of Double Monster and "Normal" and Computed Fetuses

DIMENSION USED	DIFFERENCES IN PER CENT OF COMPUTED MEASUREMENTS FROM THOSE OF OBSERVED AND CALCULATED "NORMAL" RIGHT AND LEFT FETUSES FOR:						
	VHH	THC	0.5 THC	TBW	0.5 TBW	SN-U	
	Right Left	Right Left	Right Left	Right Left	Right Left	Right Left	
CH*	−10.0	−26.8	+55.8	−17.5	+13.2	+ 3.7	observed
							calculated
BiP**	− 6.1 − 2.4	−22.7 −21.3	+58.9 +61.5	−13.9 −12.5	+16.9 +18.8	+ 6.8 + 8.6	observed
	−10.7	−26.3	+51.2	−18.1	+11.3	+ 1.7	calculated
VHH	− 9.5 −	−25.3 −	+48.0 −	−16.4 −	+11.5 −	+ 2.6 −	observed
	− 9.5	−25.3	+48.0	−16.4	+11.5	+ 2.6	calculated
CU	−13.7	−29.5	+44.9	−19.8	+ 8.9	− 1.2	observed
	− 9.3	−25.9	+52.2	−15.8	+14.4	+ 3.7	calculated
U-Pub	+33.3	00.0	+260.0	+20.0	+89.4	+63.6	observed
	−14.9	−36.2	+130.0	−23.4	+23.8	+ 4.5	calculated
TD-10-R	−29.6	−43.2	+28.2	−35.9	−10.8	−18.1	observed
	− 9.9	−27.3	+64.1	−18.0	+14.2	+ 4.9	calculated
Nip-Nip	+55.8 +53.4	+26.4 +24.5	+57.5 +58.0	+42.5 +40.4	+97.0 +94.1	+76.3 +73.6	observed
	− 9.4	−26.5	+57.5	−17.1	+14.7	+ 2.6	calculated

UEL	− 0.8 00.0 −10.6	−19.6 −19.0 −27.5	+76.0 +77.3 +58.6	− 9.0 − 8.3 −18.0	+25.7 +26.6 +13.3	+14.7 +15.6 +3.4	observed calculated
LEL	−10.1	−27.8	+62.3	−18.3	+14.6	+4.1	observed calculated

* Where the right and left dimensions as well as observed and calculated values are the same only one figure is given (as in CH).

** Where the right and left dimensions are the same only one figure is given (as in BiP as calculated).

There are a few differences in some corresponding dimensions but they are slight and are probably due to experimental error of determination.

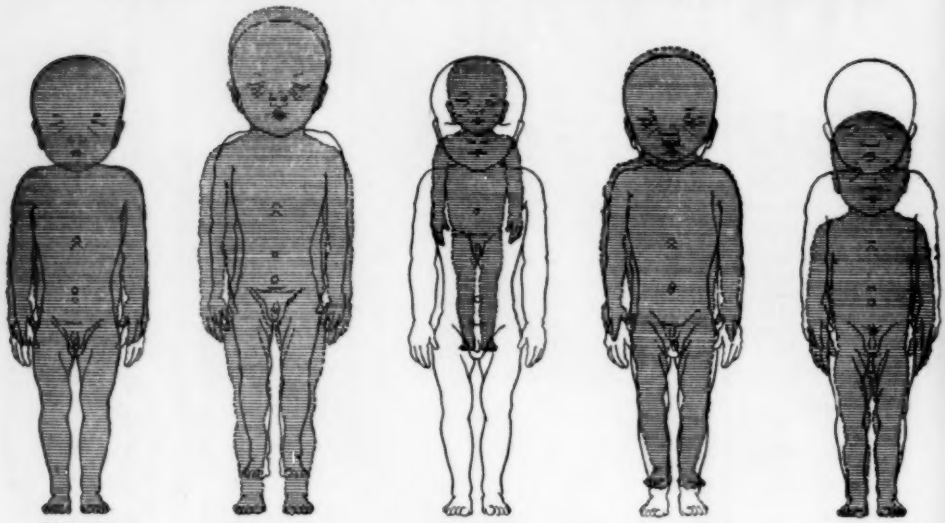

FIG. 18. A graphic comparison made by superimposing the outline of one-half of the observed double monster upon that of a "normal" fetus computed by empirical formulae from the observed body length. The outlines are oriented to total body length. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 19. A graphic comparison made by superimposing the outline of one-half of the double monster upon that of a fetus computed by empirical formulae from the observed vertical head height. The outlines are oriented to vertical head height from the menton. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 20. A graphic comparison made by superimposing the outline of one-half of the double monster upon that of a fetus computed by empirical formulae from one-half of the observed total head circumference. The outlines are oriented to total body length from the crown. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 21. A graphic comparison made by superimposing the outline of one-half of the double monster upon that of a fetus computed by empirical formulae from the observed distance from the suprasternal notch to the umbilicus. The outlines are oriented to the distance from the suprasternal notch to the umbilicus. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

FIG. 22. A graphic comparison made by superimposing the outline of one-half of the double monster upon that of a fetus computed by empirical formulae from one-half of the total body weight. The outlines are oriented to the total body length from the sole. (The computed fetus is shaded and drawn in broken line and the observed specimen is drawn in solid line.)

The graphic comparison (figure 18) of the observed measurements with those computed from the observed total body length of the

"normal," shows how closely the two components which make up the monster would have approached the "normal" had they developed as separate individuals.

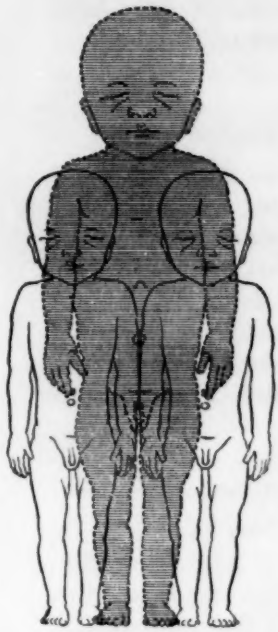

Fig. 23

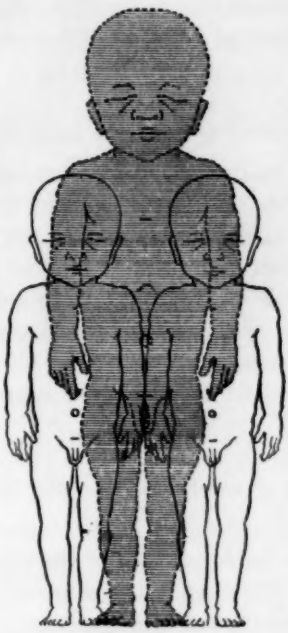

Fig. 24

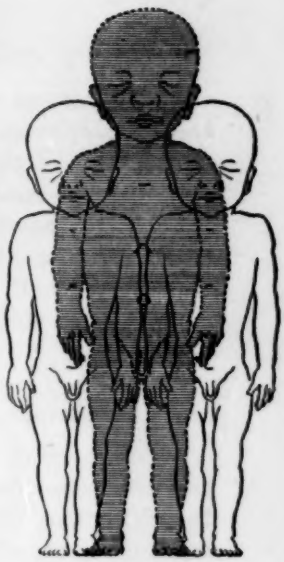

Fig. 25

FIG. 23. A graphic comparison made by superimposing the outlines of the two halves of the observed double monster upon that of a fetus computed by empirical formulae from the observed total head circumference. The outlines are oriented to the total body length from the sole. (The computed fetus is shaded and drawn in broken line and the observed specimens are drawn in solid line.)

FIG. 24. A graphic comparison made by superimposing the outlines of two "normal" fetuses, computed by empirical formulae from the observed body length of the double monster, upon that of a fetus computed by empirical formulae from the observed total head circumference of the double monster. The outlines are oriented to the total body length from the sole. (The computed fetus is shaded and drawn in broken line and the "normal" fetuses are drawn in solid line.)

FIG. 25. A graphic comparison made by superimposing the outlines of the two halves of the observed double monster upon that of a fetus computed by empirical formulae from the observed total body weight. The outlines are oriented to the total body length from the sole. (The computed fetus is shaded and drawn in broken line and the observed specimens are drawn in solid line.)

b. Comparisons of the vertical head height

The measurements of duplicate parts show such marked similarity that the most important analysis seemed to lie in a study of the regions

of fusion. Comparison of one-half of the double monster with a fetus *computed from the vertical head height* (figure 19) shows the vertical head height to be greater than that of one component of the double monster. It also shows an enlargement in all dimensions of the fetus computed from the vertical head height over those of the observed specimen.

c. Comparisons of the total head circumference

A comparison was made of a fetus *computed from the observed total head circumference* with the entire double monster. This required comparisons of the computed fetus with *two* observed fetuses each equivalent to one-half of the double monster (figure 23). The comparison gives an example of the use of this method, for in this instance no simple quantitative comparison seemed practicable. Comparison of two "normal" fetuses computed from the observed body length shows a close similarity to the observed components of the monster (figure 24).

d. Comparisons of one-half of the total head circumference

A comparison was made of a fetus *computed from one-half of the total head circumference* with one-half of the observed fetus (figure 20). In this instance the dimensions of the computed fetus are reduced to a marked degree, which supports the impression of a definite reduction in total body mass as a result of the fusion, although each component has grown to the same extent. Comparison of the computed fetus with the "normal" fetus as computed from the observed body length also supports this view. This suggests that the body length of the fetus has been reduced as a result of the fusion and this may account for the similarity between the observed and "normal" fetuses.

e. Comparisons of the distance from suprasternal notch to umbilicus

Graphic comparison in this instance (figure 21) indicates that there has been less reduction in mass of the trunk as a result of fusion than in the cephalic region. The computed fetus approaches the observed fetus much more closely than in the preceding comparison, although it is still slightly smaller than the observed component. This also holds true for the comparison of the computed fetus with the "normal" fetus. One may therefore conclude that the vertical trunk dimensions have not been greatly affected by fusion.

f. Comparisons of the total body weight

As a further test a fetus was *computed according to the total body weight* and compared graphically with the *two* observed components (figure 25). This comparison indicates that the total body weight is not equivalent to two complete fetuses, and that there has probably been definite reduction in total body mass with fusion.

Fig. 26

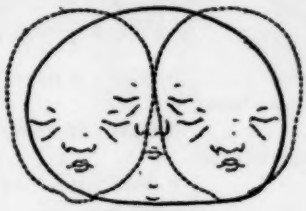

Fig. 28

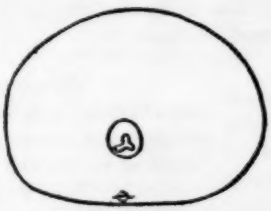

Fig. 27

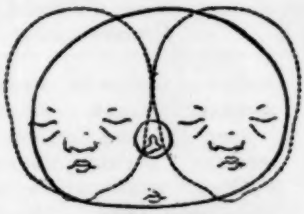

Fig. 29

FIG. 26. An outline of the more complete facial region of the double monster.

FIG. 27. An outline of the less complete facial region of the double monster.

FIG. 28. A graphic comparison made by superimposing the outlines of two "normal" heads, computed by empirical formulae from the observed body length of the double monster, upon that of the more complete facial region of the double monster. (The computed "normal" heads are drawn in broken line and the observed head in solid line.)

FIG. 29. A graphic comparison made by superimposing the outlines of two "normal" heads, computed by empirical formulae from the observed body length of the double monster, upon that of the less complete facial region of the double monster. (The computed "normal" heads are drawn in broken line and the observed head in solid line.)

g. Comparisons of one-half of the total body weight

A fetus was also *computed to one-half of the observed body weight* and compared with one-half of the observed monster (figure 22). All the dimensions of the computed fetus in this instance are definitely reduced. The same picture appears when the "normal" fetus is compared with the fetus *computed from one-half of the observed body weight.*

TABLE 6

Areas of the Facial Region

FACIAL AREA IN QUESTION	WEIGHT OF 1 CM. RADIUS CIRCLE (*gm.*)	WEIGHT OF 1 SQ. CM. (*gm.*)	WEIGHT OF TOTAL AREA IN QUESTION (*gm.*)	OUTLINE AREA IN SQ. CM.	RATIO FOR COMPARISON	REVERSE RATIO	RATIO FOR COMPARISON 0.5 OUTLINE AREA
Normal area.....	0.0652	0.02075	0.769	37.1	1.0	1.00	1.0
Less complete facial area.....	0.0650	0.02069	1.361	65.7	1.7	0.55	0.8
More complete facial area.....	0.0646	0.02056	1.365	66.3	1.7	0.55	0.8

TABLE 7

Comparison of Measurements of Selected Dimensions of Double Monster with Similar Measurements of "Normal" Fetuses

DIMENSION USED	NUMBER OF NORMAL CASES BETWEEN 30–32 CM. CH LENGTH	OBSERVED VALUE FOR DOUBLE MONSTER (*cm.*)	MEAN VALUE FOR NORMAL FETUS (*cm.*)	STANDARD DEVIATION (*cm.*)	DEPARTURE OF OBSERVED FROM MEAN (*cm.*)	RATIO OF DEPARTURE OF OBSERVED FROM THE MEAN TO THE PROBABLE ERROR OF DISTRIBUTION
BiP	13	6.25	5.95	0.948	−0.30	0.468
VHH	13	7.70	7.48	0.379	+0.30	1.176
CU	8	15.80 (0.5 total)	16.46	0.717	+0.60	1.239
NC	10	10.70	10.70	1.720	0.00	0.000
Xs-Pub	8	7.10	6.50	0.728	+0.60	1.221
TD-10-R	8	5.00	6.82	0.775	−1.80	3.441
APNipD	8	3.90	5.40	0.540	−1.50	4.118
UEL	11	13.25	11.71	0.754	+1.50	2.946
UAL	11	5.15	4.50	0.569	+0.65	1.694
FAL	11	4.50	3.60	0.721	+0.90	1.850
HL	11	3.60	3.30	0.748	+0.30	0.593
LEL	11	12.55	12.39	0.419	+0.20	0.705
Tro-Kn	11	5.25	5.50	0.970	−0.25	0.382
Kn-Mal	11	6.05	5.60	0.848	+0.45	0.786

Where the observed value represents dimensions taken from both components of the monster, the average value is given for there is in no case more than 1 mm. difference between them.

Fig. 30

Fig. 31

Fig. 32

Fig. 33

Fig. 34

FIG. 30. A superimposition of one aspect of the facial region of the double monster upon the other.

FIG. 31. A graphic comparison made by superimposing the outline of the more complete facial region of the double monster upon a normal outline constructed to an area equivalent to it. (The observed facial region is drawn in solid line and the normal outline is drawn in broken line.)

FIG. 32. A graphic comparison made by superimposing an outline of a normal face, constructed to an area equivalent to one aspect of the facial region of the double monster, upon the outline of a normal face constructed to an area equivalent to that of two "normal" facial outlines, computed by empirical formulae from the body length of the observed specimen. (The normal outline equivalent in area to one facial region of the double monster is drawn in solid line, and the outline equivalent in area to two "normal" head outlines is drawn in broken line.)

FIG. 33. A graphic comparison made by superimposing a normal outline, constructed to an area equivalent to one-half that of one aspect of the facial region of the double monster, upon a "normal" head outline computed by empirical formulae from the observed body length of the double monster. (The outline equivalent to one-half the area of one aspect of the facial region of the double monster is drawn in solid line and the outline computed from the body length is drawn in broken line.)

FIG. 34. A graphic comparison made by superimposing a normal outline, constructed to an area equivalent to that of eleven-twentieths (0.55:1) of one aspect of the facial region, upon a "normal" head outline computed by empirical formulae from the observed body length of the double monster. (The normal outline equivalent to eleven-twentieths [0.55:1] the area of one aspect of the facial region of the double monster is drawn in solid line and the "normal" outline is drawn in broken line.)

h. Comparisons of the facial outline areas

A further analysis of the head region has been undertaken, for the graphic analysis of these dimensions indicates that this was the

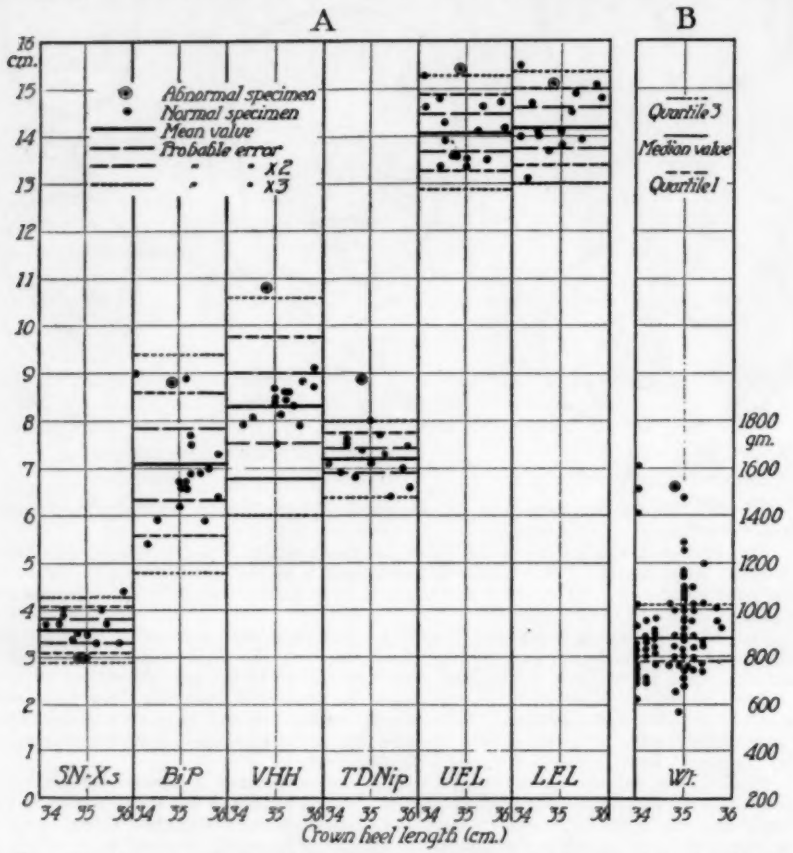

FIG. 35. *A*; a graph of certain dimensions of the simple monster, showing the degree of departure of observed measurements from the distribution of the "normal" cases and from the mean value for normal specimens of approximately the same body length. *B*; a graph of the weight of the simple monster showing the degree of its departure from observed weights of normal specimens of approximately the same body length.

region of greatest modification in growth. This study was concerned primarily with the areas of the outlines of the frontal aspects of the head, including the faces of each side. The measurements were obtained and tabulated as previously described. This permitted the analysis of each facial area with respect to the "normal" area

and to one another. Figures 26 and 27 illustrate each area plotted to scale, and figures 28 and 29 show each area compared with two "normal" ones.

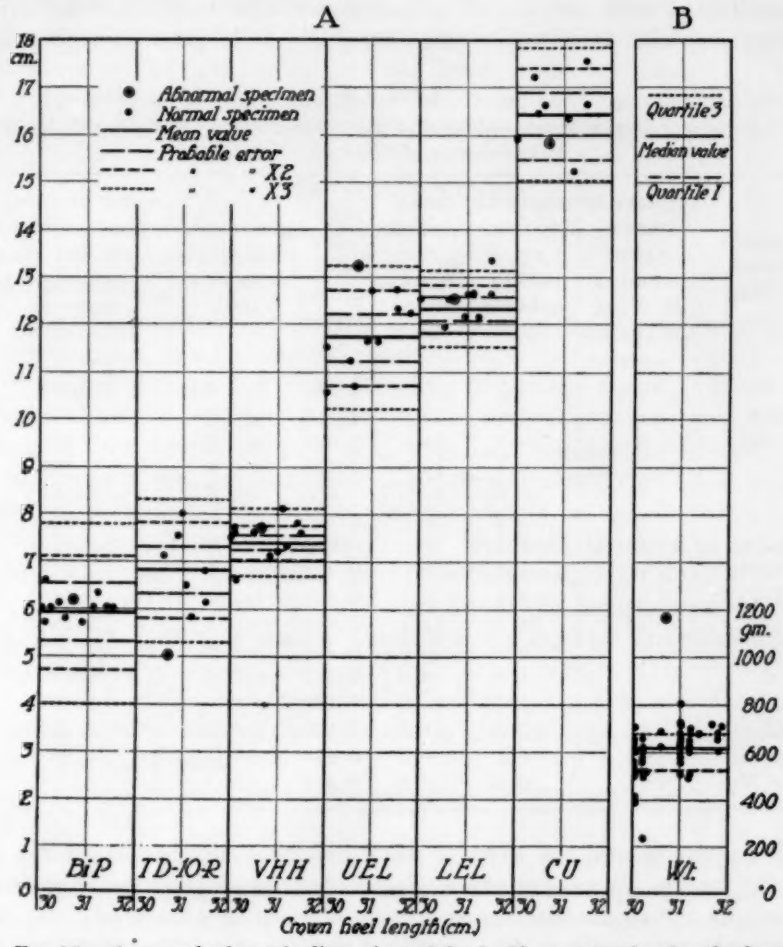

FIG. 36. *A*; a graph of certain dimensions of the double monster showing the degree of departure of the observed dimension from the distribution of the "normal" cases and from the mean value for normal specimens of approximately the same body length. *B*; a graph of the weight of the double monster showing the degree of its departure from observed weights of normal specimens of approximately the same body length.

It is generally accepted that in this type of monster the anterior cephalic fusion is a product of the portions of the face on one side of the midline of both components. Figure 30 compares the two facial

regions. Table 6 shows that the ratio of areas between the normal and observed heads is approximately 1:1.7. Accordingly, an area 1.7 times that of the normal head area, of normal facial outline, was constructed with the aid of a planimeter, and each observed area compared with it. One of these comparisons is given in figure 31.

TABLE 8

Comparison of Measurements of Selected Dimensions of Simple Monster with Similar Measurements of "Normal" Fetuses

DIMENSION USED	NUMBER OF NORMAL CASES BETWEEN 34–36 CM. CH LENGTH	OBSERVED VALUE FOR DOUBLE MONSTER (*cm.*)	MEAN VALUE FOR NORMAL FETUS (*cm.*)	STANDARD DEVIATION (*cm.*)	DEPARTURE OF OBSERVED FROM MEAN (*cm.*)	RATIO OF DEPARTURE OF OBSERVED FROM THE MEAN TO THE PROBABLE ERROR OF DISTRIBUTION
BiP	18	8.7	7.0	1.183	+1.6	2.001
VHH	15	10.8	8.3	1.168	+2.5	3.171
SOBC	18	28.5	25.8	5.696	+2.7	0.702
CU	13	19.1	19.0	1.436	+0.1	0.102
NC	14	19.0	12.5	1.656	+6.5	5.853
SN-Xs	13	3.0	3.6	0.371	−0.6	2.391
Xs-Pub	13	7.3	7.5	0.634	−0.2	0.474
TDNip	14	8.9	7.2	0.435	+1.7	5.784
APNipD	14	8.1	6.1	0.658	+2.0	4.545
UEL	15	15.4	14.1	0.602	+1.3	3.198
UAL	15	6.2	5.6	0.376	+0.6	2.400
FAL	15	4.8	4.6	0.587	+0.2	0.510
HL	15	4.4	3.9	0.303	+0.5	1.665
LEL	15	15.1	14.2	0.620	+0.9	2.148
Tro-Kn	15	6.7	6.5	0.349	+0.2	0.867
Kn-Mal	15	6.9	6.5	0.392	+0.4	1.584

By computing the areas of each observed head to the ratio of 1:1.7, one may compare a face of normal outline (equivalent in surface area to 1.7 times the "normal" area) with an area equivalent to *twice* the "normal" or the combined surface of *two* "normal" heads (figure 32). This permits a comparison of the observed area with that of a possible doubled area resulting from the fusing of two "normal" heads.

As the ratio of "normal" area to observed area was 1:1.7 comparison was made with a one-half ratio, or a normal outline equivalent to 0.85 of the observed surface area. This comparison was made with

both the observed facial areas. It shows a much closer fit, approximating the two "normal" facial areas. Figure 33 illustrates the very slight difference between the one-half and the "normal" area.

Figure 34 gives a reverse ratio for comparison. Since the normal area had a ratio of 1:1.7 with respect to the observed area, the ratio of the observed area to the "normal" area would be 0.55:1.

The results of this examination of a composite monster are given in résumé in the second part of the following general summary.

GENERAL SUMMARY

The study of the simple monster indicates that:

1. The digression in growth of this monster followed the "law" of developmental direction.

2. The greatest deviation in growth occurred between the suprasternal notch and xiphisternal junction.

3. The cranial and caudal regions have developed at different rates of growth but each region has followed the "law" of developmental direction in an independent fashion. Development caudal to the region of greatest digression in growth seems to have been dependent on a secondary center of growth control in this region. The development of the cranial region of the body has been relatively rapid and that of the caudal region of the body relatively slow.

4. Growth in total body length has been greatly retarded as a result of failure of development in the region of the xiphisternal junction.

5. The ratios of segments of the appendages to the complete members were normal in contrast to the findings of Nañagas for anencephalic fetuses.

The results obtained from a study of the compound fetal monster indicate that:

1. The components forming the double monster tend to equal and normal "duplication." Fusion of the two components has had very little effect on their individual development other than incompleteness in the area of fusion. The areas of fusion show marked growth deviations, particularly in the facial region.

2. Fusion had apparently little effect on the relations of the various external dimensions to the total body length of each component.

3. There is no evidence of establishment of secondary centers of growth control as a result of the cranial and thoracic fusion.

4. The growth of the double monster seems to have followed the "law" of developmental direction, and the growth gradients of both components seem to have been practically identical.

5. There has been a definite reduction in body mass of the composite monster associated with fusion.

ABBREVIATIONS OF DIMENSIONS

(Given in order of appearance in tables)

CH	Crown-heel length
VHH	Vertical head height
UEL	Upper extremity length
LEL	Lower extremity length
SN-Xs	Suprasternal notch to xiphisternal junction distance
BiP	Biparietal diameter
SN-Pub	Suprasternal notch to pubis distance
TDNip	Transverse diameter at nipples
UAD	Upper arm diameter
TD	Thigh diameter
UAL	Upper arm length
FAL	Forearm length
HL	Hand length
Tro-Kn	Great trochanter to knee distance
Kn-Mal	Knee to lateral malleolus distance
FL	Foot length
NM	Nasion to menton distance
AVH	Auriculo-vertex height
SOFD	Suboccipito-frontal diameter
OMC	Occipito-mental circumference
SOBC	Suboccipito-bregmatic circumference
SOBD	Suboccipito-bregmatic diameter
SOFC	Suboccipito-frontal circumference
Xs-Pub	Xiphisternal junction to pubis distance
Xs-U	Xiphisternal junction to umbilicus distance
SN-U	Suprasternal notch to umbilicus distance
THC	Total head circumference
0.5 THC	One-half total head circumference
TBW	Total body weight
0.5 TBW	One-half total body weight
CU	Crown to umbilicus distance
U-Pub	Umbilicus to pubis distance
Nip-Nip	Nipple to nipple distance
TD-10-R	Transverse diameter at tenth rib
NC	Neck circumference
APNipD	Anteroposterior diameter at level of nipples

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RACIAL MIGRATION-ZONES AND THEIR SIGNIFICANCE

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PART I

One of the most interesting problems in human biology deals with that period of man's history which included the later Ice Ages and much of post-glacial time, but which ended long before history commences. This period saw man separate into various races and subraces, and saw him spread into the ends of the earth. A great deal of attention has been given to the criteria which best determine racial differences, much less attention has been given to the routes by which the primitive races reached their modern habitats, very little attention has been directed to the changing conditions which must have accompanied these racial changes and these racial migrations. Yet it seems to the writer that these three variables (criteria, migration routes, and environments) must be linked together in any study of early man which pretends to be at all complete. In one small corner of the world, Europe, a good deal of progress has been made by combining the work of the ethnologist, the topographer, and the climatologist, and in the present paper I wish to show that the general principles which determined the early history of the races in Europe and the adjacent regions hold good in regard to races in the less known parts of the world.

Some ten years ago I was asked by a Government department in Australia to study the general habitat of the so-called "Yellow Race," naturally with reference to Australia as a suitable environment for those peoples. I soon found, of course, that these folk were already inhabiting the most diverse environments with a range at least as large as that of the so-called "White Race." But I was struck with the resemblance of the racial movements in the Southeast of Asia to those of Southwest Asia, and furthermore I found little evidence for the generally accepted racial divisions which isolated eastern

Asiatics from central Europeans, or eastern negroes from African negroes.

One major trend of ethnology has clearly been to ally the narrow-headed West-European peoples first with North-Africans, then with Semitic-speaking folk, and finally with the people of India. My local knowledge of that complex belt of races situated between Asia and New Zealand led me to believe that ethnologists should extend the racial allies of the West-Europeans much further east than India,—indeed, through the East Indies right to the north island of New Zealand. Further study made it probable to me that this same group of peripheral folk in the Old World had many representatives among the aborigines of America. I investigated these problems by means of isopleths and three-dimensional diagrams such as some geographers have used for many years. The results were published in the *Geographical Review* (New York) in 1919 and 1921.* I believe that this method of attack was new to ethnologists, and it has certainly led me to conclusions considerably at variance with many generally accepted ethnological hypotheses.

"THE ZONES AND STRATA" CONCEPT

I can best explain my own belief with regard to the "mechanism" of these racial migrations by reference to a concept which I described in 1919 and which in other fields must be known to many interested in the subject. It is in effect the fundamental principle behind the "age and area" theory of Willis in botany—or that propounded by Mathew in zoology and by Wissler in cultural anthropology. I may illustrate this by a personal experience. Some years ago I was travelling in the interior of Australia some 200 miles from Sydney, and happened to meet an ox team conveying the goods and chattels of a "bush" family to a new district. Returning nearer to Sydney—within about 150 miles—I came across one of the old buses (which I remember plying in Sydney about 1895 or so) still actively engaged in traffic in this outer zone. Within 100 miles of Sydney the motor-buses dominate transport. In Sydney itself we see many more aeroplanes than in any other part of the State (see Fig. 1, at right).

If now we investigate the archeological relics in the "dump" of an engineer's yard in Sydney we shall find fragments of aeroplanes,

* Climatic Cycles and Evolution. Vol. viii, No. 6 (Dec., 1919), pp. 289–328. Evolution and Distribution of Race, Culture and Language. Vol. xi, No. 1 (Jan., 1921), pp. 54–119.

overlying parts of motor-bus engines, and these in turn heaped over bits of horse-drawn vehicles. At the bottom may be some mouldering yokes of the ox teams which left Sydney fifty years ago. These relics are of course to be found in similar order under the outer zones also, as is shown in the section at the front of the block diagram in Figure 1. Everyone can interpret this sequence. It is clear that this series of zones (ox team, horse-bus, motorbus, aeroplane) is the same as the series of strata. But the most significant deduction is that this sequence implies (a) that the *most primitive* type is pushed to the periphery and (b) that the *most advanced* type occurs in the centre of the zones, where the stimulus (commercial in this case) has been greatest.

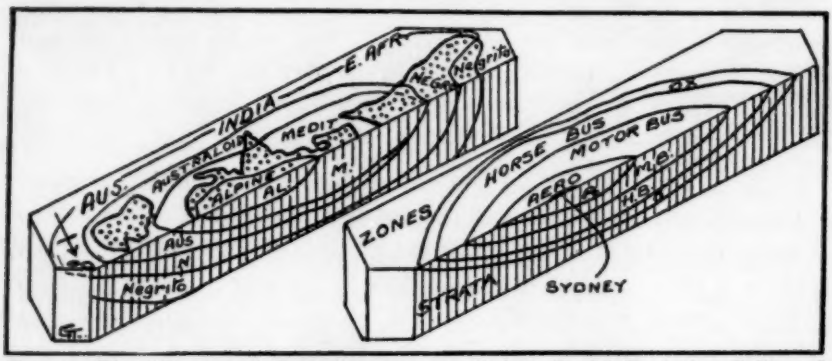

FIG. 1. The "Zones and Strata" concept applied to Racial Evolution (left) and Transport Evolution (right).

I hope to show that a series of racial zones centering about south central Asia is clearly demonstrated by my racial isopleths (see Fig. 1, at left). All racial history shows that the *dominant* movements of early man (wherever we can reconstruct them) have been centrifugal from Asia. (See Fig. 10.) Two very interesting deductions may be referred to here which I have never seen stressed in current anthropology. We found the ox team flourishing today precisely where it *did not originate;* for in Australia its original site was certainly Sydney. So, also, the discovery of a primitive skull in South Africa or Australia to my mind has no bearing on the site of the cradle-land of man. Rather it tells us where *not* to look for a cradle-land. Secondly, if the concept outlined above (which we may call the "Zones and Strata" concept) is true, then some of those broad-headed folk in or near Turkestan are indicated as the last types of man to develop

in the stimulating cradle-land of man. Many anthropologists will deny that one race is physically higher or better or later than another. Most anthropologists will say that we have insufficient knowledge to debate the matter. As a student of human ecology the writer cannot see any escape from the conclusion that these folk in central Asia on the borders of the Alpine and "Mongolian" territory are later and physically higher types of man than the West European (Mediterranean), just as the aeroplane is a later and higher type of transportation than the ox team.

THE DISTRIBUTION OF AREAS

Let us consider briefly the general plan of the earth in regard to this problem of Human Ecology. We are so accustomed to maps which stress the central position of Britain or of the United States that we are apt to forget that through the greater part of racial history these habitats were of little or no human importance. The topographer will point out that the land areas of the world (excluding Antarctica) consist of a central Asiatic land-mass with three peninsulas projecting therefrom. The southwest peninsula consists of Europe and Africa. This we may term *Eur-Africa*. The northeast "peninsula" is *America*. The southeast "peninsula" comprises that quarter of Asia, with the East Indies and Australasia. We may conveniently call it *Austral-Asia*. We know that the Asiatic land-mass by virture of its huge area dominates the climates of the world. Here are the greatest extremes of temperature, pressure and rainfall, as well as the greatest elevations and largest low-level plains (See Fig. 10). The environment of today offers more variety in Asia than elsewhere, and this was no less true in earlier epochs.

Anticipating what I hope to show later, we may assume that man became an important and relatively abundant animal first of all in south central Asia. If circumstances arose which caused him to abandon his early home, is it not logical to assume that his early migrations would lead him toward *all three peninsulas*, unless we can demonstrate that unfavorable conditions blocked any one of the routes? Summing up the climatology in the periods under discussion, I think we can postulate inclement conditions blocking the American route for a time, so that the earlier migrations went impartially either into Austral-Asia or Eur-Africa. Later the American corridor became available and the later migrations thereupon went impartially into the *three* peninsulas. (See Fig. 11.) This geographical method of

considering early man would lead us to expect a zonal distribution of the races of man, whereby allied primitive races are found in *each* of the regions most distant from Asia; whereby allied intermediate races are found in the nearer portions of the "peninsular" continents; whereby the latest stocks are still found in or near the central landmass of Asia, or the "corridors" therefrom. This racial plan is almost precisely what the evidence indicates, in the writer's opinion, if we throw overboard the preconceived idea that the West-European is necessarily the latest developed and "highest" type of man.

CRITERIA OF RACE

One of the greatest difficulties in ethnology is to determine the value of the criteria which have been used to identify a race. The earlier investigators like St. Hilaire and Huxley used skin color as the main test. Topinard and Deniker used the texture of the hair. Ripley, in the most complete study so far made of a large region, used the head index (breadth expressed as a percentage of length). Dixon uses head index mainly. The writer in his recent book* has used the two most widely accepted criteria, head index and hair.

The two sketch maps here reproduced (Figs. 2 and 3) are based directly upon the most complete anthropological atlas of maps with which the writer is familiar. They are from Biasutti's *Antropogeografia Generale* (*Florence*, 1912). In my own book (*Environment and Race*) the maps were based on other data, for I had not seen Biasutti's work when they were drafted. But it is perhaps more convincing to use data collected without connection with the "Zones and Strata" concept.

ZONES OF HEAD INDEX

In the head index map (Fig. 2) there are seen to be two regions where the head index is very low, below 75 per cent One of these is in Africa, the other in Australasia. These are clearly peripheral positions with respect to Asia. As regards America there are almost no relics of early man, though the skull found at Punin in Ecuador (just below Mt. Chimborazo) is stated to have a head index of 71 and to be "basically related to those found in Australia and Melanesia." It was associated with Pleistocene mammals (Sullivan and Hellman. *Am: Mus: Nat. Hist.* July, 1925).

* Griffith Taylor. "Environment and Race." *Oxford*, 1927. See discussion of criteria, Chapter IV.

The next zone contains those intermediate races so variously named "Mediterranean," "Hamitic," "Ethiopian," "Nesiot,"

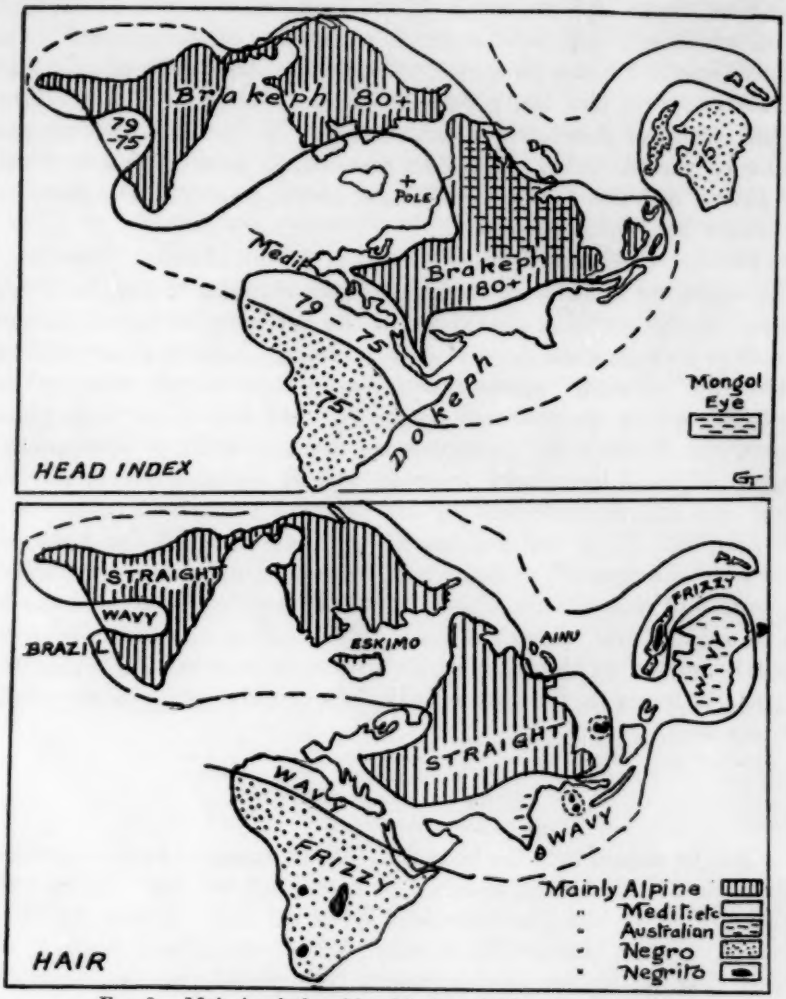

FIG. 2. Main isopleths of head index, chiefly after Biasutti.
FIG. 3. Main isopleths of hair texture, after Biasutti.

"Brown," "Caspian," etc. All have dolichokephalic (dokeph)* skulls with indices ranging from 79 to 75. They are most abundant

* I trust that other ethnologists will find these contractions "dokeph" and "brakeph" as useful as I have.

in North Africa and West Europe and South Asia. These are now generally accepted as genetically related. But further research to the East shows us many tribes in the East Indies and in South East Asia which can only be correlated with the "Mediterranean" type of the west. So also in northern Japan are Ainu, who certainly are neither negroid like the peripheral peoples nor brachykephalic (brakeph) like the peoples of most of Asia. In America also we find relics of various tribes, chiefly on the central west coast and inland in Brazil, who are narrow-headed and also approach to the Mediterranean stock in other respects.

Finally the mainland of Eurasia is dominantly "brakeph." The skulls are globular, with indices often reaching as high as 88 per cent. There is no line of division at the Urals, separating the broadheads of Europe from those of Asia. Even in Eastern Asia the characteristic "Mongol" appearance is based on relatively unimportant criteria such as the shape of the eyelid* (see Fig. 2) or of the cheek bone. In America the aborigines are predominantly of this brakeph stock, which I have been tempted to call Alpine-Mongolian. But they are not characterized by the Mongol features in most parts of America. It is common knowledge that many of the Amerinds have a "European" rather than "Mongol" appearance—which is true also of many of the allied Polynesian peoples. The explanation is simple. These Amerinds and Polynesians are genetically more closely related to the Alpine folk of Europe than to the "Mongol" type still living in the east of Asia (though the latter is essentially Alpine also).

ZONES OF HAIR TEXTURE

If it be argued that the head index is not accepted by some anthropologists as a sufficient measure of race, then we may consider the distribution of the characteristic types of hair. Using the three major types as charted by Biasutti, frizzy, wavy, and straight, the map (Fig. 3) shows almost exactly the same zonal arrangement. In the peripheral "peninsulas" are found the frizzy-haired races, corresponding to the peripheral zone of folk with very narrow heads. The zone of wavy-haired peoples almost exactly agrees with those with skull indices from 75 to 79. Finally the main portion of Asia, and almost all America, was occupied by straight-haired folk. Here

* Biasutti, *loc. cit.* (1912) p. 67.

again it is worth noting that the Amerind tribes had hair less straight than that of most of the *East* Asiatic folk. It is very slightly waved like that of the people on the *western* border of the "Mongol area," i.e. in western Siberia, Tibet, and Siam. There is little doubt surely that the Amerinds and Polynesians represent a disrupted zone of peoples akin to the Alpines of Europe who once occupied the eastern littoral and hinterland of Eurasia, as the Alpines of Europe occupy the western hinterland of Eurasia today.

If we compare more closely the generalized maps shown in Figures 2 and 3 we find only two *noteworthy* racial divisions where the isopleths of hair and of head-breadth do not agree. One of these is Australia, where the aborigines have narrow skulls (73 to 75), but their hair is wavy; not curly as it is often described.* This race is therefore

Table Correlating Geographical and Ethnical Zones

MIGRATION ORDER	RACE	GEOGRAPHICAL POSITION	SKULL-BREADTH INDEX	HAIR	RACIAL STATUS
5	Alpine	Central in Asia Europe and America	Over 80	Straight	*Latest* developed
4	Intermediate, Mediterranean, etc.	Marginal Europe South Asia East Asia South America	79–75	Wavy	Intermediate position
3	Australian	Peripheral	75–73	Wavy	Developed after negro
2	Negroid	Peripheral in Eur-Africa, Austral-Asia	Under 75	Frizzy	Early evolved
1	Negrito	Inaccessible areas in periphery	Aberrant	Frizzy	Earliest evolved

somewhat disharmonic, since elsewhere wavy hair is associated with rather broader skulls. The second group, the negritoes, merits special discussion. For the rest we may say that the races of the world almost entirely agree with the correlations given in the table. (I have added the last column, though it has not been discussed adequately yet.)

Thus it must be admitted that there is a definite series of zones in the Old World surrounding the south center of Asia. In these

* Taylor and Jardine. "Kamilaroi and White." *Roy. Soc. N. S. Wales'* Dec. 1924 (p. 285).

zones skull-breadth and hair-texture are the criteria, and they lead from a peripheral frizzy-haired, narrow skull, through a wavy-haired, intermediate skull to a central straight-haired, broad skull.

At first glance America seems to be an exception to the above rule, but if we consider the time-factor, then in this region also the migrations have been of the same general type. It is generally accepted that the earliest American migrations of noteworthy size (e.g., excluding the Punin type) were in a state of Upper Paleolithic culture. Therefore they probably entered America (by the Bering route) long after the Neandertal and negroid folk had colonised the southern parts of the Old World. They found an empty continent at their disposal, which improved in character as they advanced southwards. Naturally these later migrations spread out quicker from the racial "corridors" here, and covered more ground in America than where they were hemmed in by earlier migrations (as in Europe) or by the sea (as in southeastern Asia). Even in America we see evidence of the earliest migrations (consisting as usual of narrow-headed folk) being pushed to the wall in Greenland or into the hills and jungles of far distant eastern Brazil. Furthermore, the eastern tribes (Algonquin, Tupi, etc.) have narrower heads than those living in or near the corridor.

THE ABERRANT NEGRITOES

There is, however, one small group of tribes—the negritoes—which to my mind resists all simple methods of classification. Their essential ethnic traits are very short stature (under 5 feet), very frizzy hair, very broad nose, but a head index usually over 80. Using our locational criterion, their habitat is invariably in the most inaccessible portions of the peripheral domain. Thus they occur in distant islands (as in the Andamans and Philippines) or in the densest jungles (as in the Congo region or in New Guinea). It seems evident to me that they represent one of the earliest, if not the earliest, migration of man.

How shall we explain their broad-headed skulls? Those ethnologists who place little reliance on skull indices say that they are merely a special variation of the negro. The writer cannot accept this view, for the negro is specifically a tall member of the human race. Moreover, there are other features, such as the convex upper lip, the well developed beard, the well shaped legs, which also differentiate them from the surrounding negroes. The negritoes of the Congo are remark-

ably like those of the New Guinea mountains—much more alike than are the African negroes and the tall Papuan negroes. This would hardly be the case if each stock of negritoes had developed independently from the taller negroes—owing, as some ethnologists say, to their relatively unattractive habitat. Why forest life should produce a broad skull the protagonists of the negro-origin theory do not explain.

The second theory (advanced by Dixon)* suggests that they are genetically associated with the other great group of broadheads, the Alpines. Dixon gives no convincing explanation as to why the negritoes developed the peppercorn variety of the frizzy negroid hair, or the other physical features in which they differ even more from the Alpine than from the negro type. Further, their complete isolation from any broad-headed races in Africa, Papua, and the Andamans makes it difficult for me to understand how these primitive folk ever developed from the Alpines, whose whole racial history (so far as we can construct it) has been so different.

The third theory, which I advance in default of a better, is that the negritoes are derived from an early human stock, which gave rise to no other modern races. In other words, we are to imagine two "precursors" of man, a smaller type which developed into the negrito, and a larger precursor differing mainly in the character of the skull, and not unlike a generalised Neandertal man. This latter gave rise to the Negroid and Australoid types, from which in turn the Mediterranean and Alpine races evolved later. The negritoes were early driven into unstimulating environments and therefore did not evolve.

RACIAL MIGRATIONS

This investigation of racial history from the geographical standpoint reminds me of the investigations into the general principles of evolution in the classic period of the "sixties" of last century. The final court of appeal as regards evolution is surely the paleontological record, which is still imperfect today, and was lamentably so in 1860. But the "trends" of paleontological evidence were clear even then to those who would study them dispassionately. The writer believes that the trends of "paleo-ethnology" are clear enough today, though in large areas of the racial map the "fossil" evidence is still almost lacking.

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* R. B. Dixon. "Racial History of Man." *New York*, 1923.

It is with a view to clarifying this evidence and to assist in linking surface distribution with paleo-ethnological data that I have made use of the three-dimension "block diagram." Racial migrations have many features in common, which we may dwell upon briefly. Generally speaking, there were definite lines of migration in the early days which have been referred to as "corridors." Thus the Palestine-Suez region was one well-used corridor. The East Indian "corridor" led to Australia, the Bering "corridor" to America. The races spread out, forming "wave-fronts" as the corridors opened out into favorable environments. Succeeding migrations used the same corridors and pressed the older "waves" forward so that the earliest migrations are found furthest from the corridor. In so doing they usually swept around highland areas where relics of the preceding migration survived as "inliers." They also swept right over portions of the earlier "wave," submerging them so that they can be detected only by paleo-ethnological investigation. This consists, of course, not only of the study of actual human remains, but of place-names, languages, cultures, etc. The principle of "superposition" applies to paleo-ethnology just as much as to paleontology. When I speak of the "trends" of paleo-ethnology I mean that almost invariably wherever we investigate the "fossil" evidence we find that the Alpine data overlie the evidence denoting a "Mediterranean" habitat (using the word Mediterranean as a general term for the racial allies discussed earlier). Furthermore this in turn overlies the Australoid and Negroid, while the latter overlies the negrito. Of course in places one race is missing, constituting the "unconformity" with which we are so familiar in paleontology.

Only in Europe, North Africa, and a few places in Asia is the evidence at all complete, but I may be permitted to quote Dr. Marett (of Oxford)* who describes my "zones and strata" concept as a "working hypothesis of singular breadth and completeness." For it seems to me that ethnology is poorly off as regards working hypotheses, in spite of the enormous mass of valuable data which has been accumulated in the last fifty years.

Part II

I propose now to examine in somewhat greater detail the migrations with their zones and strata in the two "peninsulas" of the Old World. To the east is Austral-Asia, to the west is Eur-Africa.

* *London Mercury*, Feb., 1928. Reviews in Anthropology, p. 492.

MIGRATIONS INTO AUSTRAL-ASIA

In Figure 4 the essentials of the migrations into the southeast portion of the Old World are indicated. The grand corridor in this part of the world in part consisted of the East Indian islands, which are arranged like stepping stones to Australia. Furthest from the Austral-Asia corridor are the negritoes and negrito-hybrids. By our general rule these constitute the earliest migration. Of these are the Mincopi, Tapiro, and Aeta, with probable allies in the Semang (of the Malay States) and the Tasmanians. The latter are quite unlike

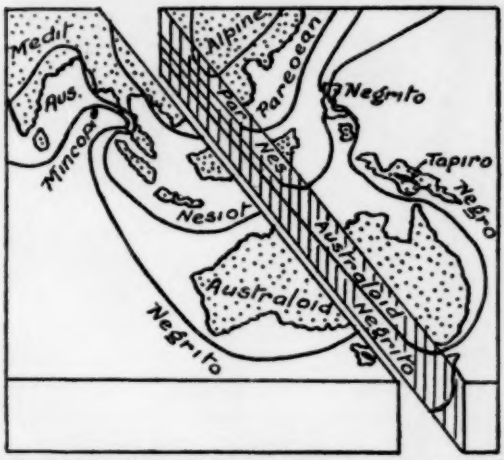

FIG. 4. A generalized block diagram showing the zones and strata above the corridor from Asia into Australasia.

the Australian aborigines, for they had broader heads, frizzy hair, and convex upper lips. In all these respects they agree with the Tapiro, though they are too tall to be accepted as close allies. The next, the *negro* migration, is fairly closely associated with the negrito habitats, but does not appear to have been anything like so important as the negro migration to Africa, which will be discussed later. However, these eastern negro peoples followed the same corridor as the negritoes toward Papua, possibly finding the route directly to Australia not so attractive. (In my book* I show that the straits have certainly varied greatly in width during man's migrations, while the north of Australia has at times been much more arid than it is at present.)

* Environment and Race." Chap. V. Changing environment in Australasia.

The third migration comprised the Australoids, who are racially akin to millions of Pre-Dravidians still living in southeast India. The Sakai of the Malay States, the Toala of Celebes, and tribes with submerged Australoid traits in southeast Asia generally show that this Australoid migration originally covered a large area in Asia. They passed by Papua and found an extensive but unstimulating environment in the isolated continent of Australia. No doubt they drove the Tasmanians before them. The Talgai skull (found in southeast Queensland, and doubtfully associated with Pleistocene remains) has some Tasmanian characteristics.

The East Indian islands are now inhabited chiefly by two races, the Indonesian (Nesiot) and the Malay (Pareoean, etc.). The former has a head index 76 to 78, black hair often tinged with red, and a tawny skin. It is probably a modified Mediterranean type but has merged largely with the next migration. Haddon thinks the Muruts of Borneo are fairly typical, but Dixon groups these with the negroid races.

The writer feels that areas where the races are so intermingled as in the East Indies are best considered in connection with adjacent areas where the racial zones are broader. Thus in India we find that the Australoid, Mediterranean (i.e. Ethiopian or true Dravidian) and Alpine races are much more readily separated. The Indian distribution gives the clue to the tangle in the East Indian archipelago.

The next zone in the East Indies is also not sharply marked. It consists essentially of what are termed Malays; but study in southern China, in the Phillippines, and in Japan shows that there is a great similarity of peoples in all those regions. Hadden has coined a new word, Pareo-ean, for these "bordering peoples," which is being adopted generally. They are brachykephalic and straight-haired, but shorter and often slighter than the typical Alpine peoples of Asia. The last zone shown in Figure 4 consists of these latter folk, who become purer in type as we move north through China. Throughout the tangle of great ranges which terminate the Himalayas on the east there are many "inliers" of earlier migrations. Thus the Wa of upper Burmah seem to show some Australoid characteristics. The Lolo nearby are often described as "European"—meaning that they are browner, more leptorhine, and narrower-skulled than the surrounding hordes of Alpine-Mongolian peoples. No doubt the Lolo are akin to members of the "Mediterranean" zone.

RACIAL COMPOSITION OF "MELANESIANS" AND "POLYNESIANS"

Few names have been so misleading in ethnology as "Melanesian" and "Polynesian." These are of course regional names only, but they are still often used as if they were of racial value. Some of the few untouched racial regions in the world still occur in Melanesia. For instance, Rennel Island, some 50 miles long, was unknown scientifically until two of my own former students studied its topography and ethnology in 1927. There is no satisfactory racial map of Melanesia—which is usually taken to include the islands to the east of New Guinea as far as Fiji (see Fig. 5). It is clear that we are dealing with at least

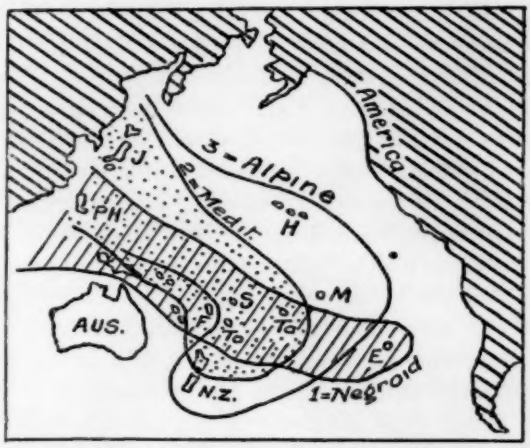

FIG. 5. Migrations into the Pacific (generalised, and partly after Dixon). Initials indicate Easter Is, Fiji, Hawaii, Marquesas, New Zealand, Samoa, Tahiti, Tonga.

three major racial migrations. Generalizing somewhat we may say that the first comers were the more primitive tribes who are definitely negroid and are allied to the Papuans. They now occupy in general the western islands of the Melanesian "festoons." Later occurred a migration of tribes somewhat broader-headed, lighter in color, and slighter in build. There is no satisfactory name for these, and they are no doubt much mixed both with early negroid and later Alpine races. It seems likely that the widespread stone-cult is associated with this migration. Without further evidence we cannot be sure how close in kin they are to the Nesiot-Mediterranean tribes, though this is precisely where we should expect representatives of that great stream to be found. The terms "Massim," "Papuo-Melanesian,"

"Caspian" (Dixon), "Sepik type," refer to groups in this major migration. They occur in New Guinea and among the islands of the Solomons and New Hebrides, etc. Finally, on the western margin of a few of these islands are relatively pure groups of the last great migrating race, the Alpines of Polynesia.

The problem is just a little clearer in the scattered islands of the Pacific. It is still customary to say that these are inhabited by a "Polynesian Race." But here again, in my opinion, we are dealing with at least three distinct migrations. Dixon has classified the skull material, and his conclusions are somewhat as follows.* There was first a dominantly negroid migration which reached from Melanesia as far east as Easter Island (see Fig. 5). Mrs. Routledge† has shown how closely the artifacts of Easter Island resemble those of the Solomons. This migration no doubt occupied many of the Melanesian isles also. The second major racial migration (for doubtless there were many small migrations) consisted dominantly of the "Caspian" type—by which Dixon means a stock closely akin to that which invaded North Europe from the Caspian region. They are found widely distributed from Japan to New Zealand (N. Isle). They had skulls of medium width, lighter skins, wavy hair, and more leptorhine noses than the earlier migration. Their abundance in New Zealand results in the remarkable resemblance between some Maoris and West Europeans—for these are practically brothers. They are also dominant in the Gilbert Islands on the equator.

The third major type consisted of Alpine folk with broad heads who left eastern Asia, perhaps only a few millenia ago, and spread everywhere throughout Polynesia—except perhaps Easter Island. They are found dominantly so far apart as Hawaii, Samoa, and southern New Zealand. Thus the term "Polynesian" has no racial significance, and this island region—like the Melanesian region—contains essentially the same three migrations arranged in much the same order of strata. In Melanesia we have noted that these three migrations are arranged approximately in zones—primitive to the west and later to the east (see Fig. 5).

The main features of the migrations from southeast Asia have now been briefly presented. In every case they moved outwards from Asia, and in general, though the evidence is not complete yet, we may say that the migration zones and strata support the thesis mentioned

* Dixon, *loc. cit.*, pp. 377 *et seq.*

† Mystery of Easter Island.

earlier, i.e., the migrations were in the order negrito, negro, Australoid, Mediterranean (Nesiot, etc.), Alpine.

MIGRATIONS INTO EUR-AFRICA

Let us now turn to the other corner of the Old World and study the human ecology in the Eur-African section of the Old World. I have discussed their distribution fairly fully in *Environment and Race* but I will summarise it here. The first point of interest is that the same rule holds good which we have observed among the Austral-Asian zones. The most primitive are found in the most inaccessible regions. These, to the wanderer from Asia, are the center of the Congo forest and the Kalahari desert. Three criteria serve to separate the races in these areas from the rest of Africa, i.e., hair character, skull index, and their remarkably low stature. In both are pygmy races with head index around 80 and with hair even more tightly "kinked" than that of the negro, so that it is described as the "peppercorn" type. It is curious that the purer negritoes are found in the dense forests (just as are the Tapiro) while the Bushmen in the southern desert (like the Tasmanians) are almost certainly hybrids with negrito.

The chief racial boundary in Africa is the line separating the negroid people from the Hamitic groups of North Africa. It runs from Cape Verde to Zanzibar. The Hamitic tribes, of course, are merely a branch of the Mediterranean or "Brown" Race discussed previously. They are also the dominant folk in Europe on the north coasts of the Mediterannean Sea. The negroes, however, are separated into two major groups, the Sudanese tribes and the Bantu tribes. The division was originally linguistic, which is theoretically purely a cultural distinction. But in general the Bantu-speakers are a higher type (presumably a later type) than the negro who dwells in Guinea and in the Sudan. The Bantu has a somewhat broader head, a narrower nose, and other features approaching those of the more northern peoples. It is often stated that the Bantu is merely a hybrid between the Sudanese type and the Hamitic (or Mediterranean) stock, and probably this is the best explanation. But I am not yet sure that the Bantu developed *in Africa* along the border line of the two more distinct races specified. It is possible that he came into Africa as a later migration from Asia. It is significant that the Australoid migration occupies an analogous position in the southeast between the Mediterranean and negroid zones—but unlike the Australoid,

the Bantu possesses hair of the same type as the true negro. The general opinion is that the Bantu only occupied the South African plateaux within the last one or two thousand years, and that his home before that was somewhere near Uganda. It is worth noting that some of the tribes (e.g. Fula) in the Upper Niger region speak languages akin to the Bantu group. I have indicated these zones and strata in Figure 6.

The discovery of several ancient skulls in South Africa and the available data as to certain tribes recently extinct there in part enable us to disentangle the strata in South Africa. Thus the Taungs skull (Kimberley) is of the ape-man type, probably akin to the Trinil skull in Java. The Boskop (Transvaal) skull is provisionally allied by Dixon* with the extinct Strandloopers of the Cape, while the Broken

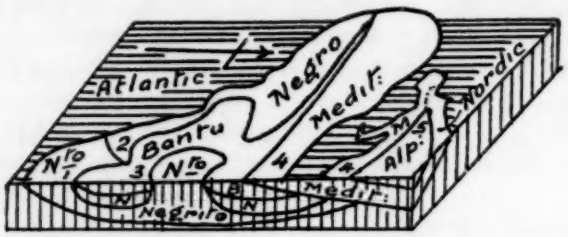

FIG. 6. A block diagram of Eur-Africa (looking west) and indicating the chief racial zones and strata.

Hill (Rhodesia) skull is perhaps of a later type and represents a primitive negroid or Neandertal type.

The Vaalpens (or Earthmen) of the Transvaal were pitch-black pygmies who differed from the Bushmen in language as well as in certain physical respects. They seem to have been near the Congo negritoes. The Strandloopers (or Shore-runners) lived on the coasts of Cape Colony and were short but not dwarf peoples with larger skulls than the Bushmen. These were also less dolichokephalic. Peringuey describes them as allied, as regards tools and culture, to Aurignacian man of Europe.

In the annexed cross section (Fig. 7) I have attempted to link these data as presented by Dixon, Keane, and others. We are concerned here as elsewhere with at least two primitive stocks, the negrito and negro. Dixon separates the negro into high-skull (Proto-negroid) and low-skull types, the latter of whom he somewhat unfortunately

* Dixon. *loc. cit.*, pp. 180 *et seq.*

names Proto-Australoid. Thus the first migrants seem to have been largely pure negritoes, and probably the Vaalpens are closely allied. The Strandlooper is a mixture of negrito and proto-negroid and so also perhaps is the Boskop type. The Bushman, in Dixon's words, may be regarded as a Strandlooper in whom the Mongoloid (e.g. low broad-skull element) has been relatively weakened by the addition of a considerable Proto-negroid factor. The Broken Hill skull is essentially a "Proto-Australoid" negro. The Hottentot is a mixture of the latter with the Proto-negro, the former being dominant. The Zulu (a typical Bantu stock) is essentially Proto-negroid with a large admixture of Proto-Australoid.

North of the "negro line" we reach races which are closely akin to some in Europe. The history of early man in Europe is moderately

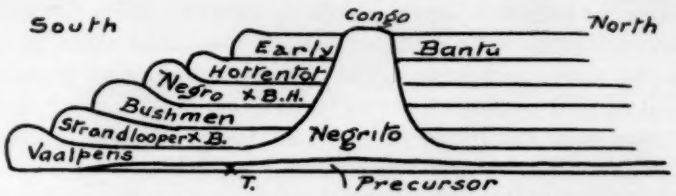

FIG. 7. An attempt to reconstruct the racial strata in South Africa. T. = Taungs; B = Boskop, B.H. = Broken Hill.

well known. Generalizing we may state that the earliest important stratum consisted of the Neandertal types of early Paleolithic times. It is usually stated that these died out and have no connection with the living races of today. Yet in many important criteria the negroid and Australoid types approached the Neandertal. The latter lived in France before the last (Wurm) Ice Age, so that we are dealing with a period of 80 or 100 thousand years ago. It is not unlikely that while Neandertal man was migrating into Southern Europe, an allied migration reached central Africa or the Siam region. While I consider that human evolution is relatively slow in the unstimulating environment of the Tropics, I see no reason to believe that it was negligible. The logical conclusion to my mind is that some early type akin to Neandertal did develop in the space of 100,000 years into races now classified as African negroes and Melanesian negroes. The Broken Hill skull from Rhodesia may be described as proto-negroid or as proto-neandertal. Some Australian aborigines have skulls of this type. Thus in 1922 Burkitt and Hunter* described a recent Neandertaloid Australian

* *Journal of Anatomy, Cambridge*, Oct., 1922.

skull exhumed at Tamworth (New South Wales). In their own words it had "an enormous development of the superciliary ridges and glabella, a comparatively well developed bregmatic eminence, a marked development of the torus occipitalis. Added to these primitive features are an extremely low sloping forehead" . . . and a cephalic index of 65.

It is of considerable interest that a number of skeletal remains in Europe have been described as Proto-Australoid. This is the case with a number of skeletons found at Brunn. Fleure* describes living people in central Wales as Neandertaloid. Other scattered evidence seems to show that the Australoid layer—so obvious in India and the southeast of Asia (including the Philippines)—was represented in a lesser degree by a migration into southern Europe. But it has not persisted here as a definite zone as it did in the southeast of the Old World. The evidence for the negrito stratum in Europe is also still rather indefinite. The curious technique of Bushman art is carved on rock surfaces from north to south of Africa. It is similar to carvings from the Pyrenees and from India. I refer to other evidence in *Environment and Race*. We may, I think, assume that a negrito stratum (in the Paleolithic times of West Europe) extended through most of the southern lands of the Old World.

I wish to draw attention to the remarkable parallel arrangement of these zones in the southwest and southeast of the Old World. (In the following table the latest "strata" appear above. I have used 'Polynesian' and 'Melanesian' in the sense explained above.)

This method of arranging the data seems to me to point definitely to the fact that both sets of races spread out from some common cradle-land, which *a priori* would naturally be the center of the zones or racial isopleths already discussed in the maps. This concept is approximately indicated in the diagram (left) in Figure 1. Otherwise we must surely postulate two separate cradle-lands for the negritoes, two more for the negroes, and yet two more for those curiously alike racial stocks, the Western Europeans and the later Polynesians. As I hope to demonstrate, it is far simpler and just as well supported by our scanty paleo-ethnological data to assume one cradle-land for all the races concerned—in south central Asia. Moreover, I feel sure that the dispassionate reader will agree that the definite geographical distribution has a biological explanation—which can hardly be other

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* Fleure and James. *Journ. Anthrop. Instit., London*, 1916.

than what was indicated by the "Transport-evolution" analogy sketched in Figure 1 (right).

Race Parallels in Southwest and Southeast of the Old World

MIGRATION	ENVIRONMENT	RACE	HEAD INDEX	EUR-AFRICA	AUSTRAL-ASIA
Latest	Nearest Asia	Alpine	80+	Central Europe	Siam and China
"	Eastern islands	"	"	Hovas of Madagascar	Later "Polynesians"
Intermediate	Borders of Europe and Asia	Mediterranean	75–77	Mediterranean	Higher "Melanesian." Some Micronesian. Early "Polynesian."
Early	Cooler parklands	Later Negroid	73	Bantu-speakers	Australoids
"	Equatorial parklands, etc.	Negroid	72	Guinea and Sudan	New Guinea and southern "Melanesia"
Earliest	Farthest southern areas	Negrito Hybrids	Variable	Tasmanians	Bushmen
"	Inaccessible forests	Negrito	"	Negritoes	Tapiro, Aeta

THE RACES OF EUROPE

We may now consider briefly the races in Europe itself. There is general agreement that the three main types are Mediterranean, Nordic, and Alpine. Of these, the two former are linked by a common skull-shape, but separated by the color of the skin and hair. The Alpine folk are broad-skulled, shorter, perhaps straighter-haired than the other two, and are more sharply marked off from them than is the Nordic from the Mediterranean. Owing largely to the much more complete historical evidence in the Mediterranean region and in Egypt, etc., we are fairly clear as to the origins of the Mediterranean race. They entered Europe (after the Cro-Magnon migrations of Magdalenian times) toward the close of the upper Paleolithic period. They moved into West Europe from North Africa, and their kin still live in the latter region and extend across Arabia into central India, etc.

The Alpine folk entered Europe a little later, between 12,000 B.C. and, (as Fleure says) 6,000 B.C. and we have a clear idea of their path from the Pamir region across the Black Sea area as far west as the Pyrenees. But as regards the Nordics the evidence is much more scanty.

Sergi many years ago suggested that their undoubted resemblance to the Mediterranean race could be explained by assuming that the Nordics were "bleached Africans" who were modified by life in the Baltic areas. The modern theory is that they came from west Siberia, and this is supported by a good deal of archeological evidence. The first important stratum in the Russian plains consisted of the "Kurgan" tribes, whose skeletons in the Kurgans (tumuli) are largely narrow-headed (like the Nordics). The modern Slav of Russia is essentially the result of the submerging of this early Nordic (?) stratum by hordes of later

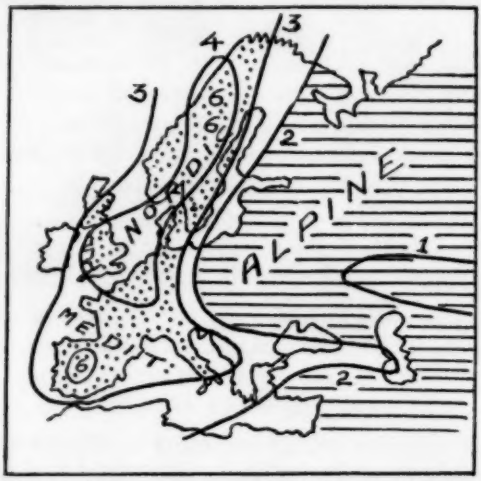

FIG. 8. Blood tests of European peoples, slightly simplified from Hirszfeld and Steffan. Indices under 2 correspond to Alpine Race and extend east to the Pacific. Indices over 3 correspond to Nordic and Mediterranean races.

Alpine peoples. The Kurgan folk may be represented fairly closely by the modern Finns and the east Bulgars, who are much more "dokeph" than the other dwellers in the great European plain.

One would like to dwell on the languages of these early migrants, but space does not permit. However, the writer is strongly of the opinion that the Aryan tongues were introduced mainly by the Alpine broadheads; and only a few centuries B.C. replaced Hamitic tongues in Ireland and Wales,* where Aryan languages are now spoken by narrow-headed folk of the Mediterranean race. So also it is possible that many of the Nordic peoples originally spoke languages akin to Finnish or Magyar but learnt modified Aryan speeches which ultimately became Teutonic languages.

* See Rhys and Jones, "The Welsh People." *London*, 1900.

One interesting corroboration of the theory that the Nordic and Mediterranean races are akin on the one hand, while the Alpine and "Mongolian" are allied on the other, is furnished by some of the recent blood-test research. No one yet understands precisely how these agglutination indices are going to help us in ethnology, but the recent map given by Steffan (in *Rassenphysiologie*, Munich, 1928) and based largely on Hirszfeld's data shows some interesting relations (see Fig. 8). Thus almost uniformly low indices extend from the Baltic Sea to the Chinese coasts. I have long believed that no essential differences separated the Alpines of Europe from the dominant peoples of central and eastern Asia. So also all the western and southwestern parts of Europe are marked by very high blood indices, so that from this point of view there is little to choose between the Nordic and Mediterranean races. Furthermore, it is interesting that the blood tests of Australian aborigines are also very high, as if they were to some extent akin to the West Europeans. But it must be admitted that the few figures given for African negroes seem to group them with races with which they have no affinity in the present writer's opinion. However, in Europe and Asia the indications are very suggestive.

CLIMATIC CHANGES IN EUROPE

The early relations of these three European races may be dwelt on for a moment. There is little doubt that they all evolved in Asia, for all our data show them coming in from the east. The key to their present distribution is found in the changing environment in Europe during late Paleolithic times. It is common knowledge that the environment of Europe changed for the better during post glacial times. Ignoring small fluctuations we may picture the north of Africa as being quite attractive to man during the later ice ages. As the rainy belt moved north (following the ice) numerous races left the (now) arid littoral of Africa and moved into Europe in large numbers. This in part explains the great migrations of the true Mediterranean peoples. In turn central and northern Europe changed from tundra through steppe to forested country. Early man, to a great extent, kept to that environment to which he had become accustomed. He would know, of course, nothing of this slow movement of flora and fauna, which extended through thousands of years.

In Figure 9 I have combined into a block diagram, necessarily generalised, some of the correlated data with regard to these environ-

mental changes in the Scandinavian region. The general sequence is well understood. The ice cap is indicated as in the far north of Norway; though actually today it occurs only in patches on the high plateaux, as at Justedals Brae. The Tundra is, however, present today along the northern littoral of Europe around the White Sea. It merges into a cold steppe. The most northern trees are firs, then come oaks, and the most southern zone is beech—which is today one of the most typical trees in north Germany. We are able to estimate the position of the retreating ice front by dating the great terminal moraines. Two dates are shown, i.e. when the ice halted in north

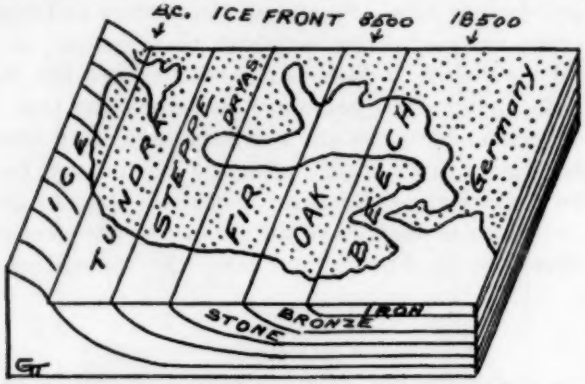

FIG. 9. Block diagram (generalized) showing the northward movement of zones in Scandinavia from 18,500 B.C. onward. Corresponding human migrations are indicated on the front edge.

Germany about 18,500 B.C. and again in 8,500 B.C. in south Sweden. More significant results, however, are obtained from the "fossil" evidence. In various parts of the Baltic region we find data which are indicated in cross section in the diagram. Thus relics of oak and fir forests are found below the present-day forests, but above the steppe and morainic debris of the last Ice Age. Most important is it to note that the artefacts of the later stone age are usually associated with the fir "stratum," while those of the bronze age can be correlated with the oak stratum, and those of the early iron ages with the beech stratum (see Peake and Fleure*). We have here, therefore, almost a complete picture of the migrations of primitive man, and of their control by climatic changes acting through the varying modifications of the flora and fauna.

* "Corridors of Time." 1927, *Oxford.*

CLIMATIC CHANGES IN ASIA

I do not propose to discuss the well-known alternations of Ice Age and Interglacial in Europe. But it is worth noting that the climatic changes were almost certainly as important in Asia, although not marked by so great a development of land ice. It is now recognized that the development of large areas of snow and ice depends on an adequate supply of water equally with adequately low temperatures. In fact, two of the most striking results of the writer's study of these problems in the Antarctic in 1910–11–12 were (a) that the land ice is stagnant or receding in Antarctica and is accomplishing very little in the way of erosion; (b) that ice-free regions (as on the west of

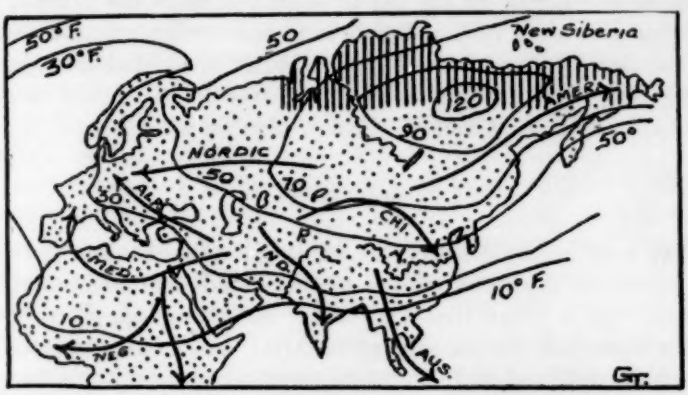

FIG. 10. Map showing greater annual range of temperature in Asia than elsewhere. The ruled area shows the Asiatic region glaciated (v. Molchanov). The arrows indicate some of the main corridors of migration.

Macmurdo Sound) can occur in areas under the same temperature conditions as those of enormous masses of land ice. However, Antevs in his recent book, *The Last Glaciation* (New York, 1928), discusses the remarkable changes in climate in Asia during Quaternary (e.g. Human) times. Most of the area north of 62° N. according to Molchanov was heavily glaciated, although it is nearly at sea level (see Fig. 10). This includes a belt along the Arctic Ocean perhaps 300 miles wide—now occupied by tundra. All the highlands of Siberia were also heavily glaciated. In southwest China in the Yun-Ling Mts. (Y in Fig. 10) the snowline is now at 18,050 feet, but in the Pleistocene was 4,600 feet lower. In the Pamirs continental ice developed. In Turkestan the glaciers descended 3,300 feet lower than now. In the Himalayas four separate ice-ages have been identified, so that

we may conclude that the variations in Asia were similar in kind and degree to those of Europe.

Paleo-botanical evidence is equally striking. In the New Siberia Isles (75° N.) there are records of an earlier glaciation, followed by a meadow environment, then by forests of birch and alder with mammoths (Fig. 10). Later a second ice age developed, followed in turn by dwarf forests which gave place to the tundra of today. The trees described now grow at least 5 or 6 degrees of latitude south of the islands. Thus environmental fluctuations in Asia during the last half million years have been at least as profound as those in western Europe. Indeed, if we compare for a moment present-day conditions in Asia with those in Europe we are led to assume that in the time of early migrations they were very probably still more striking than in Europe. Thus the present annual temperature range is plotted in Figure 10, showing that most of Asia has a range over 50° F., while in almost all Europe and in all Africa it is below that figure.

CONCLUSIONS

I may now briefly describe the environmental changes and migrations which, in my opinion, led to the zonal arrangement already described. It is clear that the racial chronology in West Europe does not represent the chronology in Asia. As I have tried to show elsewhere it took about 2,000 years for the bronze culture to spread across Europe from east to west. The Neolithic Culture perhaps took 6,000 years for the same journey. It is conceivable that earlier cultures took ten times as long, while the actual early migrations of man from the cradle-land may well have been determined by climatic changes in Asia which occurred 50,000 or 100,000 years before the particular migration reached Western Europe. It is, of course, only in this latter region that we have been able to link them up with the ice-age chronology.

I confess that I cannot understand how ethnologists ignore the implications of the three following generally accepted statements: first, that man has divided into the various major races during the last half million years; secondly, that the evidence supports the view that all these races came from some point between central Africa and north Australia, presumably central Asia; thirdly, that remarkable—indeed, almost catastrophic—changes in environment occurred in central Asia precisely during this period.

So many critics do not realize that primitive man, up till say 10,000 years ago, was influenced in his mode of life mainly by the abundance of his food supply. I do not think that such stimuli as trade or zeal for discovery or even the desire to conquer weaker neighbors bulked very largely in the period while the races were differentiating. We do not know when this differentiation occurred, but it was surely long before the dawn of history. The farther limit of our chronology is probably Pliocene times, for several examples of true man have been found in early Pleistocene times in outlying portions of the Old World, e.g. Piltdown (England), Broken Hill (Rhodesia), Talgai (Queensland). Neandertal man lived in West Europe during the last great interglacial (Riss-Wurm) and also during the following Wurm Ice Age. Negro and negrito man appeared in Europe possibly a little later, if the Grimaldi skeletons (of Monte Carlo) are of post-Wurm date. The true Mediterranean races with Tardenoisian culture reached Europe about 10,000 B.C. Alpines came into Europe somewhat later, about 8,000 or 7,000 B.C., and the Nordics perhaps about 5,000 B.C.

I have attempted to illustrate the long lapses of time involved in the earlier migrations in the following table. It is, of course, only suggestive, for we have no idea of the chronology except around the Mediterranean Sea. It may be noted that David* has given evidence for dating the Tasmanian (negrito?) migration into Tasmania before the Wurm Ice Age, while the Punin (negroid) skull of Ecuador may be as old as this also. However, what I want to make clear is that in my opinion the evolution of the Mediterranean type, *in Asia*, occurred far earlier than its appearance in Europe, while the evolution of the negro *in Asia* may have to be set back to the Riss-Mindel Interglacial or even earlier. This is all speculation but none the less worthy of a little attention. (In the table *later* strata are above.)

The paleo-ethnical strata so far investigated by ethnologists have largely been in the peripheral regions of the Old World. If the "zones and strata" concept is correct, then we should and do find only one or two of the most primitive strata in such places as Tasmania and Cape Colony. As we approach nearer to Persia or Turkestan we should find more and more strata. In France and Spain, for instance, we have Alpine and Mediterranean over negroid over Neandertal. In India Alpine (Mahrati), over Mediterranean (Dravidian), over Australoid (Santal). In Turkestan very little archeological research has been done, but the presence of narrow-heads below the

* T. W. E. David, "Johnston Memorial Lecture." *Roy. Soc. Tasmania*, 1924.

dominant Alpine stock is described by Sergi and Tavorski. The presence of early paleolithic cultures in Siberia and on the Ordos plateau in north China* indicates that the paleolithic (Neandertal) races lived there. Still more primitive skulls are of course known from several parts of Asia already.

The finest field for research in paleo-ethnology is surely in Turkestan, where it seems likely the record of man's history will be much

Tentative Chronology, illustrating Trends†

ESTIMATED DATE	CLIMATIC EPOCH	RACE IN WESTERN EUROPE	AFRICA	CENTRAL ASIA
5,000 B. C.	Mild to warmer climate	Nordic, Alpine		
10,000–20,000	Four minor Ice Ages	Mediterranean Cro-Magnon	Mediterranean?	Alpine?
40,000–100,000	Wurm Ice Age	Negroid Neandertal		
	Wurm-Riss Interglacial	.....	Negroid?	Nordic? Mediterranean?
200,000	Riss Ice Age	Piltdown?		
	Riss-Mindel Interglacial	.....	Rhodesian skull?	Negroid?
400,000	Mindel Ice Age	Heidelberg?		

more complete than, for instance, in such an outlying area as France. Indeed, if early man developed most quickly in the stimulating postglacial environment of Turkestan there is nothing surprising in Pumpelly's† dating the earliest city civilisations there about 10,000 B.C. It seems likely that this was the work of Alpine peoples, who were no doubt the dominant race in those parts long before this date. Recent changes chiefly marked by pronounced desiccation largely account for the present backward condition of these peoples, but in those broadheaded tribes at the centre of the zones—such as the Tajiks, Galchas, and Kirghiz—the writer sees the latest developed of the human race.

It must be remembered that the climatic stimuli in Asia during the development of man led to a southward movement of the flora and fauna during each oncoming Ice Age, and to a northward retreating

* Licent and Teilhard de Chardin. "Paleolithique de Chine," *L'Anthropologie, Paris*, 1925.

† Pumpelly, "Explorations in Turkestan," 1907.

movement when the Ice Age waned. In this pulse I see one major factor in the production of the racial zones. Let us assume that the negroid type developed in Turkestan from some precursor during the Mindel-Riss Interglacial. As the Riss Ice Age environment moved southward that zone with which the negro was familiar moved south also—possibly five or six hundred miles. After many millenia it retreated north again. No doubt many of the negroes slowly returned north to near the original homeland, where in the ensuing 100,000 years or more of the Riss-Wurm Interglacial they evolved into a higher type of man. But we may picture some of the early negro migration isolated by straits, mountains or deserts, so that they did not return but stayed in an environment which gradually became less and less

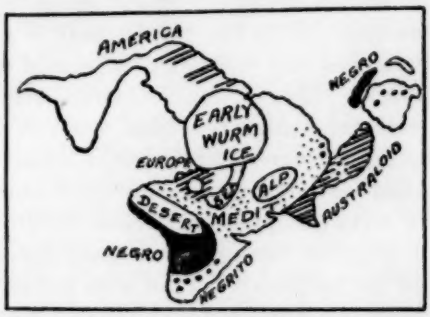

FIG. 11. Tentative map of racial distribution about the start of the Wurm Ice Age. Pleistocene coasts are only indicated. The Alpine race develops (somewhat later) where indicated. Negrito shown by large dots.

stimulating as the climate became warmer. Here they stagnated,—in other words did not change much from their original proto-negro character. (We can see the same effect of isolation in the case of the Polynesian Alpines.) When the next great (Wurm) Ice Age (see Fig. 11) drove south the more highly evolved tribes who now lived in the more stimulating environment (we may call them "Mediterranean" for purposes of illustration), the migration of these higher types drove the negroes further into the tropics, and so the process went on.

Elsewhere* the writer has endeavored to suggest how physiological changes in such bodies as the pituitary, thyroid, and adrenal glands may have been brought about by the changing climates of Asia during the racial history of the major races. It is likely that the ethnic criteria giving rise to the Nordic, Mongol, and negroid types were

* "Environment and Race," p. 231.

profoundly affected by these changes, but space does not permit of my dwelling on these aspects in this article.

In conclusion it is to be noted that the theory of racial evolution described in this paper is likely to promote harmonious racial relations. Probably few scientists believe that the so called "white" race is inherently higher than the "yellow," "red," or "brown" races. But if we can prove that each important nation today merely includes proportions of the same world-wide racial stocks, then much of that mysterious factor in politics called "racial antipathy" should vanish.

SUMMARY

The writer describes his application (in 1919) of the "zones and strata" concept to human ecology in much the same way as Mathew has done for mammals, Willis for plants, and Wissler for cultures. He shows that the world-plan consists of a central land-mass in Asia with three peninsulas (Eur-Africa, Austral-Asia, and America). Into these peninsulas races migrating from south central Asia entered in somewhat similar "waves" or zones. Biasutti's independent maps of skull-breadth and hair texture are used to demonstrate these zones. The major races accepted are Alpine, Mediterranean, Australoid, Negro, and Negrito—arranged in geographical and ethnical zones from center to periphery. This also indicates the order of evolution, the central being the last.

It is shown that this series is present in the Austral-Asia peninsula and also in the Eur-Africa peninsula. This strongly suggests a common origin of the "paired" races in the central region of southern Asia, especially as the little "sub-peninsula" of India also shows four of the zones. Recent research on blood-tests supports the belief that the Nordic race is closely allied to the Mediterranean race, while the Alpine race of Europe is one with the dominant races in central and east Asia. Illustrations are given of the migration of floras in northern Europe while the early races were entering this region.

It is shown that the climatic stimuli, precisely during man's racial differentiation, were greater in southern Asia than in other human habitats. A tentative and naturally imperfect account of the evolution of the races in Asia follows. It is clear that the final proof will be given by paleo-ethnological research.

THE INFLUENCE OF SEX ON THE INCIDENCE OF GASTRO-INTESTINAL DISEASE*

BY KIYOSHI HOSOI, M.D. AND WALTER C. ALVAREZ, M.D.

Division of Medicine, The Mayo Clinic, Rochester, Minnesota

Some time ago it occurred to us that a study of the sex incidence of disease might throw light on many problems of etiology. Illnesses which affect men several times more frequently than women might be influenced by some habit or activity or occupation which is more or less peculiar to men, and illnesses which affect women more than men might be influenced by child-bearing or by disease of the pelvic organs. Unfortunately authorities who in the past have made such assumptions have not always tested them as they should have done by looking to see what the sex incidence is when the disease under consideration attacks infants and children. As will be shown later, in the case of cholelithiasis it is somewhat of a shock to one's cherished beliefs to learn that when stones are found in children they are met with, just as in adults, several times more frequently in females than in males.

It occurred to us also that two or more diseases dependent on the same cause, or diseases dependent one on another such as, perhaps, ulcer and carcinoma of the stomach, should have the same sex incidence. Furthermore, if a disease affects men more than women simply because men live the strenuous life, or because they do hard physical labor, one would expect to find the ratio reversed in countries where men do not live so strenuously and where women work hard in the fields.

With these questions in mind we have gathered a large mass of data from the literature. We wish this mass were more complete and we wish the figures were more trustworthy. A really adequate study of the subject would take a lifetime, and it would be almost impossible for one man to keep a bibliography up to date. Unfortunately many factors combine to diminish the value of the data which we present. As Günther has pointed out, every sex ratio should be corrected by a factor dependent on the sex distribution of the group

* Submitted for publication October 3, 1929.

of men and women studied. Obviously if three times as many women as men are examined at a certain clinic, all of the uncorrected sex ratios for diseases observed in this clinic are going to be misleading. Differences also in the age distribution of the patients must affect the frequency with which certain diseases are found.

Unfortunately so few writers have paid any attention to the age and sex composition of the cohorts studied by them that we have despaired of obtaining the necessary correction factors and have continued our work without them, hoping that in most instances the numbers of men and women were so nearly equal that no large error will enter into the computation of the sex ratios. If interest can only be excited in this problem of sex and disease, more reporters of cases will perhaps, in the future, make note of the age and sex distributions of the patients registering in office or clinic or hospital.

On account of the difficulties just mentioned, the most satisfactory data we have for comparative purposes are often those obtained from the same large cohort of patients seen during the last twenty years at The Mayo Clinic. In this clinic the sex ratio of patients registering varies considerably from month to month. In winter we see relatively more men and in summer more women, but taking one year (1926) as a whole the ratio of men to women was found to be 1.03:1.

Another difficulty which arises when one attempts to analyze data such as are here presented is that different workers even in one institution will select their cases according to different criteria; that is, some will depend on clinical diagnoses, others on conclusions drawn in the operating room, and others on the final report of the necropsy surgeon. Some sets of figures represent morbidity and others mortality; some represent observations on children, and others are based on experience with adults. It is not always easy to know which figures can be added or compared and which are more reliable or more suited to our purpose. In spite of all our care we fear that in many cases we have erred in indiscriminately adding "sheep and goats."

At The Mayo Clinic the published figures in regard to the sex incidence of peptic ulcer and gastric carcinoma represent patients operated on. At first glance, such figures would appear to be highly suitable for our purpose, but a moment's thought will show that the sex ratio must depend to some extent on the comparative willingness of men and women, often far from home, to accept operation. Actually we find that in one year (1924) 48.1 $\pm$ 1.0 per cent of the men in whom the diagnosis of duodenal ulcer was made were operated

on, while only 40.3 ± 1.7 per cent of the women were so treated. This means that the sex ratio of patients with ulcer diagnosed was 3.1:1 and of patients operated on, 3.7:1. There was no significant difference between the percentages of men and of women with gastric ulcer operated on (in 1924) and there was little difference between the corresponding figures for patients with carcinoma of the stomach. The errors introduced in this way are, therefore, less than those that would be introduced if the diagnoses were not based on careful exploration at the operating table.

It occurred to us also that at a place like The Mayo Clinic the sex incidence of a disease like carcinoma of the stomach which occurs so commonly in the later years of life might be affected by the comparative reluctance of old men and old women to travel long distances from home. Actually an analysis of the figures for carcinoma of the stomach in the year of 1926 showed that for patients coming long distances the ratio of men to women was 4.0 ± 0.4:1 while for those coming from Minnesota and its border states the figures were 3.1 ± 0.4:1. This difference is suggestive and according to our expectation, but since it is only one and a half times its probable error it cannot be stressed.

We should like to have obtained more data in regard to the sex incidence of disease in childhood and old age, when the gonads are not so active, but unfortunately most collectors of statistics do not list their cases so that one can separate children from adults. Even when they give age distributions they often include in one group children aged from ten to fourteen years and adolescents and perhaps mothers of families aged from fifteen to nineteen years, or if the age distributions are given properly the several groups are not always divided according to sex. As a result we have frequently been unable in the groups of cases listed to distinguish between children and adults. The present condition of the literature can be well seen from the fact that when Potter reviewed records of 226 cases of cholecystitis in childhood he found that in ninety the sex of the patient was not mentioned.

We should like to have collected more data in regard to the sex incidence of disease of the body in general so that they could be compared with those obtained in the field of gastro-intestinal disease, but some publication now seemed advisable because one of us (K. H.) is leaving Rochester to assume new duties and it may be some time before he can return to a more careful and extensive analysis of the problem.

TABLE 1

Congenital Malformations of the Digestive Tract

	Males	Females	Ratio
CONGENITAL ATRESIA OF THE ESOPHAGUS			
Plass, 1919	18	20	
Collected, 1912–1929*	4	2	
	22	22	1:1
DIVERTICULUM OF THE ESOPHAGUS			
Starck, 1900	95	69	
Vinson, 1925	31	4	
Günther, 1927	113	44	2.6:1
Collected, 1910–1925	11	3	
	250	120	2.1:1
CONGENITAL PYLORIC STENOSIS			
Grulee and Lewis, 1917	12	3	
Goldbloom and Spence, 1920	133	30	
Thomson (Comby, 1921)	83	17	
Heusch, 1922	343	103	3.3:1
Palmer, 1922	37	10	
Findlay, 1923	58	21	
Strachauer, 1923	15	1	
Still, 1923	210	37	5.7:1
Seifer, 1927	27	7	
Monrad, 1927	179	49	3.7:1
Ochsenius (Günther, 1927)	10	4	
Collected	52	16	
	1,159	298	3.9:1
HIRSCHSPRUNG'S DISEASE			
Kleinschmidt (Grosser, 1922)	69	19	
Reuben, *et al.*, 1923	54	16	
Judd and Thompson, 1928	42	15	2.8:1
Collected	5	1	
	170	51	3.3:1
MECKEL'S DIVERTICULUM			
Mitchell, 1897	35	4	
Porter, 1905	100	30	3.3:1
Turner, 1906	121	29	4.2:1
Wellington, 1913	201	64	3.1:1
Rolleston, (Stengel, 1926)	9	1	
Collected	11	2	
	477	130	3.7:1

* In this and other tables the cases listed as "Collected" represent a few collected by us here and there in the literature. Some valuable papers are not listed because the cases published have been included in statistical studies made later by some one else. We have spent much time in trying to avoid the relisting of the same cases.

The list of papers and books consulted is now so large that we have not attempted to publish it but have given in the tables only names and dates. Anyone who finds difficulty in locating a particular paper can get the full reference by writing to one of us (K. H. at Albany Medical College).

More details in regard to the problem of sex and disease can be found in articles by Ehrström (1921), Grosser (1922), Draper (1925), Günther (1927), and Sydenstricker (1928).

CONGENITAL MALFORMATIONS OF THE DIGESTIVE TRACT

A glance at table 1 shows that congenital atresia of the esophagus occurs with the same frequency in both sexes. Diverticula of the esophagus have been seen twice as often in men as in women (eight times as often at The Mayo Clinic). Congenital pyloric stenosis, Hirschsprung's disease of the colon and Meckel's diverticulum occur three or four times as frequently in boys as in girls. The sameness of the sex incidence of these three conditions is curious, and it is curious also that almost the same ratio is met with when one comes to study gastric ulcer and gastric carcinoma. Strange to say diverticula of the small bowel, other than Meckel's, are found with the same frequency in men and women. Diverticulosis of the colon, which may perhaps be based on congenital defects, occurs two and a half times more often in men than in women.

INFECTIONS OF THE DIGESTIVE TRACT

As will be seen in table 2, noma or cancrum oris occurs slightly more frequently in girls than in boys. Mumps occurs with about equal frequency in boys and girls but when it attacks adults, men appear to be more susceptible than women.

TABLE 2

Infections of the Digestive Tract

	Males	Females	Ratio
NOMA			
Loeschner, 1847	7	13	
Gierke, 1868	7	13	
Woronichin, 1887	33	53	
Springer, 1904	44	44	
Collected, 1898–1906	6	11	
	97	134	0.7:1

TABLE 2 (continued)

	Males	Females	Ratio
EPIDEMIC PAROTITIS			
Adults			
U. S. Mortality Statistics, 1925	26	27	
Meyer, 1926	6	18	
Meyer and Reifenberg, 1926	6	19	
Schiff, 1926	11,377	5,493	2.07:1
	11,415	5,557	2.06:1
Children			
Graham, 1913	97	125	
U. S. Mortality Statistics, 1925	43	43	
Meyer, 1926	64	43	
Meyer and Reifenberg, 1926	68	43	
Schiff, 1926	4,083	3,380	1.21:1
Wiese, 1926	73	42	
	4,428	3,676	1.20:1
GASTRIC PHLEGMON			
Andre (Noir and Lafont, 1923)	32	6	
Lebert (Noir and Lafont, 1923)	26	5	
	58	11	5.3:1
GASTRIC TUBERCULOSIS			
Adults			
Broders, 1917	24	14	1.7:1
Children			
Theile, 1919	8	4	2:1
GASTRIC SYPHILIS			
LeWald, 1917	14	5	
Moore and Aurelius, 1928	60	27	
Collected, 1917–1928	37	20	
	111	52	2.1:1

TABLE 2 (continued)

	Males	Females	Ratio
ACUTE APPENDICITIS			
Fitz, 1886	197	50	
Brun, 1897	26	19	
Gordon (Brun, 1897)	58	21	
Haist, 1907	72	45	
Zimmermann, 1910	34	26	
Fowler, 1912	63	37	
Hoffman, 1912	733	297	
Deaver, 1913	2,941	1,821	1.62:1
Simpson, 1913	23	11	
Abt, 1917	45	14	
Porter, 1918	48	52	
Litchfield and Dembo, 1921	76	48	
Seifert and Augustin, 1922	739	611	
Dewes, 1922	66	37	
Lichty, 1923	49	34	
Kelley, 1923	1,424	881	1.62:1
Thompson, 1924	57	63	
Engle, 1924	158	189	
Sherren, 1924	549	387	
Sherren, 1924 (Deaths)	1,298	1,118	1.16:1
Holt and Howland, 1926	72	29	
Seeger, 1926	41	20	
Cohen, 1927	194	118	
Günther, 1927	1,712	1,747	0.98:1
Leichtenstern (Günther, 1927)	89	17	
Nothnagel (Günther, 1927)	105	25	
Matterstock (Günther, 1927)	733	297	
Albu-Rolter (Günther, 1927)	1,640	1,370	1.20:1
Guttstadt (Günther, 1927)	27,500	22,200	1.24:1
Backmann (Günther, 1927)	194	465	
Sonnenberg (Royster, 1927)	670	330	
Roux (Royster, 1927)	357	316	
Barbier (Royster, 1927)	467	149	
Suermondt (Royster, 1927)	487	513	
Loeffler (Royster, 1927)	527	627	
The Mayo Clinic, 1928	94	90	
Collected	34	21	
	43,572	34,095	1.28:1

TABLE 2 (continued)

	Males	Females	Ratio
TUBERCULOUS ENTERITIS			
Adults			
Perry and Shaw, 1893	6	2	
Hartman, 1907	105	112	0.9:1
Caird, 1921	15	26	
Lemon, 1923	34	16	
Barbier, 1925	5	6	
Branch, 1928	2	3	
Collected, 1894–1925	5	4	
	172	169	1.0:1
Children			
Mendelsohn, 1909	6	11	
Collected, 1894–1925	3	5	
	9	16	0.6:1
CHRONIC ULCERATIVE COLITIS			
Adults			
Yeomans, 1921	36	39	
Soper, 1927	8	14	
Bargen, 1927	114	86	1.3:1
Barron, 1928	34	17	2:1
	192	156	1.2:1
Children			
Helmholz, 1923	6	6	
Bourne, 1926	2	8	
	8	14	
PERITONITIS			
Adults			
Willigk, 1856	169	477	
U. S. Mortality Statistics, 1925	476	621	
Krogius (Günther, 1927)	505	348	
Giertz (Günther, 1927)	320	213	
	1,470	1,659	0.89:1
Children			
U. S. Mortality Statistics, 1925	235	264	0.9:1
PERITONITIS, TUBERCULOUS			
Adults			
Koenig, 1890	100	138	0.7:1
Osler, 1890	60	131	0.5:1
Schmitz, 1897 — Goettingen	70	19	
Schmitz, 1897 — Halle	53	21	
Schmitz, 1897 — Lindner	23	182	0.1:1
Schmitz, 1897 — Adossides	61	344	0.2:1
Bottomley, 1900	14	14	
Nothnagel and Rolleston, 1905	101	63	0.2:1
Mayo, 1921	42	153	0.3:1
	524	1,065	0.49:1

TABLE 2 (continued)

	Males	Females	Ratio
Children			
Barthez, Rilliet, (Schmitz, 1897)	53	33	
Schmitz, 1897	15	17	
Morgan, 1903	39	30	
Faludi, 1905	156	150	1:1
Theile, 1919	12	5	
Collected	16	9	
	291	244	1.2:1
PERITONITIS, PNEUMOCOCCIC			
Adults			
Carratier, 1901	14	9	
Jensen, 1903	16	24	
Cameron, 1912	3	2	
Koennecke, 1919	1	4	
	34	39	0.9:1
Children			
Annand and Bowen, 1906	25	66	
Rischbieth, 1911	25	32	
Lenormant (Clogg, 1911)	6	38	
Cameron, 1912	4	17	
Barling, 1912	5	23	
Koennecke, 1919	4	19	
Heiman, 1921	2	13	
McCartney and Fraser, 1922	12	44	
Collected	19	42	
	102	294	0.3:1
TYPHOID FEVER			
Adults			
Schiff, 1926	1,785	2,112	0.8:1
Children			
Schiff, 1926	859	869	1.0:1
Smidt, 1879	24	22	
Seifert, 1881	18	11	
Kestner, 1883	52	56	
Wolberg, 1888	154	123	
Morril, 1894	15	27	
Roemheld, 1898	64	53	
Adams, 1904	172	165	
Smith, 1911	49	51	
Barbier, 1925	43	52	
	3,235	3,541	0.91:1

TABLE 2 (continued)

	Males	Females	Ratio
PERFORATION OF TYPHOID ULCERS IN THE INTESTINE			
Adults			
Harte and Ashhurst, 1904	209	46	4.5:1
Whiting, 1910	26	4	
Collected	11	4	
	246	54	4.6:1
Children			
Harte and Ashhurst, 1904	14	10	
Whiting, 1910	3		
	17	10	1.7:1
PERFORATIONS OF THE GALLBLADDER IN TYPHOID FEVER			
Erdmann, 1903	13	12	1.1:1
TYPHOID ULCER OF THE ESOPHAGUS			
Thompson, 1903	11	1	
Collected, 1905–1917	2		
	13	1	13:1

Syphilis of the stomach has been reported twice as often in men as in women. At first glance this would seem to be due to the fact that men are more commonly exposed to the contagion, but this explanation becomes less satisfying when one discovers that a similar sex ratio has been observed with tuberculosis of the stomach. Tuberculous enteritis apparently shows no predilection for either sex.

It is curious that diffuse phlegmon of the stomach has been reported five times as frequently in men as in women. The cases are few and the probable error large, so it may be that the true ratio is lower and similar to that for ulcer.

Acute appendicitis is seen a little more frequently in men than in women. "Chronic appendicitis" is diagnosed more frequently in women because the appendix is so often removed during the course of operations on the pelvic organs. Peritonitis of all types is found more frequently in women, probably because the bacteria so often gain entrance through the fallopian tubes.

As one would expect, typhoid fever appears to attack both sexes about equally. Strange to say, however, perforations of typhoid ulcers in the intestine seem to occur four times as often in men as in women. In childhood this preponderance of males is less marked. The figures are of interest because most of the perforations probably occur while the patient is in bed, and one can hardly say then that

they are due to a greater amount of physical activity on the part of the men. Typhoid ulcers of the esophagus have been found thirteen times more often in men than in women but typhoid perforations of the gallbladder apparently affect both sexes equally. Chronic ulcerative colitis is observed a little oftener in men than in women.

DISEASES OF THE BILE PASSAGES, GALLBLADDER, LIVER, AND PANCREAS

As is well known, cholecystitis is an unusual disease of the digestive tract in that it affects women more often than men. This has always been thought to be due to the fact that women are subject to the influence of pregnancy, which possibly produces stagnation of the biliary passages together with an increase in the amount of cholesterol in the blood and in the bile. Attempts have been made to show that the incidence of gallstones is higher among married women than among the single, but unfortunately care was not always taken to see that the age distributions of the two groups were the same. This precaution is necessary because the incidence of gallstones increases with age, and it would not be fair to compare observations made on a group of young spinsters with those on a group of older married women. Gross, who recently studied this problem, concluded that there is no evidence that marriage has any influence on the development of cholelithiasis. Actually, of course, to be more exact the comparison should have been made between women who have and have not borne children. An interesting point made by Gross is that the tendency to the formation of gallstones, which, as we have pointed out, increases progressively with age, increases more rapidly in men than in women. As a result, after the age of sixty-five the ratio of women to men drops to 2:1.

Table 3, which gives the age and sex distribution of eighty-two children with cholelithiasis, shows that in infancy the disease is apparently three times as common in boys as in girls. In early childhood before the age of ten there are twice as many girls as boys, and between the ages of eleven and fifteen inclusive there are six times as many girls as boys. This ratio is maintained also when the disease attacks youths between the ages of sixteen and nineteen (the girls all nulliparous). This ratio of six girls to one boy is all the more surprising in view of the fact that in adult life the proportion drops to 3:1.

The sex incidence of cholecystitis in childhood is not easy to study because the disease is so often secondary to or associated with appendi-

TABLE 3

Diseases of the Bile Passages, Gallbladder, Liver and Pancreas

	Males	Females	Ratio
ACUTE AND CHRONIC CHOLECYSTITIS			
Adults			
Eusterman, 1924	1,394	3,584	0.38:1
Johnson and Pearre, 1926	47	413	0.11:1
Children			
Kellogg, 1923	9	2	
Potter, 1928 (cholecystitis and cholelithiasis)	62	74	0.8:1
CHOLELITHIASIS			
Adults			
Hirschfeld, 1880	98	172	
Mosher, 1901	57	58	
Candler, 1911	105	210	
Rolleston, 1914	115	153	
Zellweger, 1914	61	194	
Eusterman, 1924	2,188	6,927	0.32:1
Tanner, 1924	23	94	
Faulkner, *et al.*, 1924	6	24	
Lotzin, 1926	63	188	
Ophüls, 1926	139	67	
Günther, 1927	63	169	
Durand (Günther, 1927)	88	142	
Tanner (Günther, 1927)	107	318	
Leopold (Günther, 1927)	256	557	0.5:1
Grube-Graff (Günther, 1927)	176	764	0.2:1
Ansperger (Günther, 1927)	46	340	
	3,591	10,377	0.35:1
Children			
71 cases collected			
11 cases from The Mayo Clinic, 1890–1929			
Age			
Less than five months	6	2	3:1
From six to twelve months		2	
From one to five years	3	4	
From six to ten years	6	10	
From eleven to fifteen years	7	42	0.2:1
Adolescents			
Age from sixteen to nineteen years inclusive (girls nulliparous)	8	50	0.2:1
HEMOCHROMATOSIS			
Futcher, 1907	33	2	
Mills, 1924	13	3	
Collected	1	2	
	47	7	6.7:1

TABLE 3 (continued)

	Males	Females	Ratio
ACUTE YELLOW ATROPHY OF THE LIVER			
Adults			
Legg (Osler, 1906)	31	69	
Thierfelder (Osler, 1906)	55	88	
U. S. Mortality Statistics, 1925	162	246	
Collected, 1859–1926	7	6	
	2,554	4,092	0.6:1
Children			
U. S. Mortality Statistics, 1925	8	18	0.4:1
CATARRHAL JAUNDICE			
Flesch, 1904	14	22	
Ewer, 1905	170	171	1:1
	184	193	0.95:1
ICTERUS NEONATORUM			
Cruse, 1880	121	84	1.4:1
Elsaesser (Cruse, 1880)	75	68	
Porak (Cruse, 1880)	77	57	
Quisling, 1894	80	70	
	353	279	1.3:1
CIRRHOSIS OF THE LIVER			
Adults			
Schachmann, 1887	26	4	
Morse, 1902	47	23	
Crook, 1902	27	10	
Crook, 1902 (Deaths)	2,980	1,757	1.7:1
Rolleston, 1914 (Deaths)	22,830	18,255	1.25:1
Rolleston, 1914, 1920	600	210	2.9:1
Günther, 1927	715	120	6:1
Price (Günther, 1927)	108	34	
Eppinger (Günther, 1927)	268	104	
Bartels (Günther, 1927)	64	18	
Foerster (Günther, 1927)	24	7	
Blumenau (Günther, 1927)	154	34	
	27,843	20,576	1.35:1
Children			
Howard, 1887	35	17	
Jollye, 1892	65	37	
Woolley, 1906 (Rolleston, 1914)	48	42	
Jones, 1907	39	28	
Collected	13	10	
	200	134	1.5:1

TABLE 3 (continued)

	Males	Females	Ratio
ACUTE PANCREATIC NECROSIS			
Peiser, 1902	79	42	
Bloodgood, 1919	6	5	
Ophüls, 1926	5	4	
Abell, 1926	5	5	
Redwitz (Günther, 1927)	79	87	
Sebening (Günther, 1927)	271	290	0.9:1
Collected	4	1	
	449	434	1:1
ACUTE SUPPURATIVE PANCREATITIS			
Osler, 1906	32	14	2.3:1
CHRONIC INTERSTITIAL PANCREATITIS			
Opie, 1926	17	13	1.3:1
PANCREATIC CALCULUS			
Lazarus, 1904	47	10	
Sistrunk, 1921	1	3	
Hartman, 1925	2	2	
Seeger, 1925	5	15	
	55	30	1.8:1

citis, general peritonitis, septicemia, typhoid fever, scarlatina, and other infections which one would expect would affect boys and girls with about equal frequency. It is interesting to note, however, that Reed and Montgomery (1920), who studied cholecystitis as a complication of typhoid fever in children, found it twice as common in girls as in boys. Evidently, then, there is something peculiar about the gallbladder of even the very young female which makes it more susceptible to injuries of all kinds. Strange to say the (probably) infectious disease which produces catarrhal jaundice affects both sexes equally.

Acute yellow atrophy of the liver is seen almost twice as frequently in women as in men. Icterus neonatorum is observed with slightly greater frequency in boys. Cirrhosis of the liver has a slight predilection for men. If hard drinking were the principal cause one would expect to find the disease much more frequent in men than in women. It is noteworthy also that in 334 cases (some may be duplicates) in which cirrhosis was found in children the sex incidence was the same as in adults.

Acute pancreatic disease occurs with equal frequency in men and in women, a fact which throws doubt on the theory that the disturbance often arises secondarily to gallbladder disease. Stones in the

pancreatic ducts have been observed about twice as often in men as in women.

ULCERS OF THE ESOPHAGUS, STOMACH AND DUODENUM

Peptic ulcer of the esophagus occurs about twice as often in men as in women.

A study of table 4 and a review of one of Günther's articles will show that the sex incidence of gastric ulcer varies markedly in different countries and even in different cities in one country. Many years ago and particularly in Germany peptic ulcer was diagnosed more frequently in women than in men. That this was not due purely to inaccuracy in clinical diagnosis is indicated by the fact that some of the statistical analyses were based on necropsy reports.

TABLE 4

Peptic Ulcer of the Digestive Tract

	Males	Females	Ratio
PEPTIC ULCER OF THE ESOPHAGUS			
Cantieri, 1910	16	7	
Hellmann, 1919	13	10	
Friedenwald *et al.*, 1929	6	7	
Collected	7	1	
	42	25	1.7:1

TABLE 4 (continued)

	Males	Females	Ratio
GASTRIC ULCER			
Adults			
Willigk, 1856	46	179	0.3:1
Gruenfeld, 1883	518	632	0.8:1
Greenough and Joslin, 1889	30	157	
Perry and Shaw, 1893	52	17	
Taylor (Mayo, 1904)	72	28	
Welch (Mayo, 1904; Osler, 1906)	317	476	0.7:1
Bush, 1905	66	58	
Kreuzer, 1906	61	45	
Osler, 1906	48	28	
Rubritius, 1910	61	51	
Fenwick (Adams, Cassidy, 1913)	46	43	
Wulff, 1917	27	34	
Butsch, 1919	236	69	
Haberer, 1920	190	136	
Sherren, 1920, 1924	372	228	1.6:1
Moynihan, 1923	83	81	1:1
Habershon (Noire, Agasse, 1923)	74	128	
Bolens, 1924	49	12	
Eiselsberg, 1925	190	136	
U. S. Mortality Statistics, 1925	3,040	1,214	
Walton, 1925, 1928	228	138	1.7:1
Wilson (Martin, Sutherland, 1926)	88	38	
Martin and Sutherland, 1926	195	176	
McGlannan and Bongardt, 1926	27	1	
Lewisohn and Ginzburg, 1926	22	3	
Rolleston, 1926	4	21	
Sturtevant and Shapiro, 1926	89	31	
Hauser, 1926	370	316	
Nielson (Günther, 1927)	53	32	
Kossinsky (Günther, 1927)	7,614	17,899	0.43:1
Lebert (Günther, 1927)	69	183	
Brinton (Günther, 1927)	214	440	
Hart (Günther, 1927)	77	104	
Stachelhausen (Günther, 1927)	135	196	
Günther, 1927	863	1,617	0.53:1
Louria, 1928	47	34	
Broster, 1928	69	7	
Smith, 1928	47	160	
Miller *et al.*, 1929	52	6	
	15,841	25,154	0.63:1
Children			
Collected	39	58	
U. S. Mortality Statistics, 1925	17	24	
	56	82	0.7:

TABLE 4 (continued)

	Males	Females	Ratio
PERFORATED GASTRIC ULCER			
Dickinson, 1894	12	42	
Brunner, 1903	68	273	
Moynihan, 1907	1	12	0.1:1
Mayo, 1908	40	47	0.9:1
Petren, 1911	33	43	
Caird *et al.*, 1914	77	170	
Schoemaker, 1914	115	123	0.8:1
Scully, 1918	44	4	
Schmidt, 1922	23	11	
Prader, 1922	28	4	
Gibson, 1923	34	4	
Speck, 1923	16	12	
Bolens, 1924	13	7	
Bundschuk, 1924	12	1	
Eiselsberg, 1925	24	8	
Rolleston, 1926	4	8	
Johnston, 1926	20		
Robbins, 1926	9	1	
Hauser, 1926	27	81	0.3:1
Masson and Simon, 1927	6	19	
Crisp (Günther, 1927)	12	39	
Brinton, (Günther, 1927)	60	136	0.4:1
Bager, 1929	198	225	0.9:1
Collected, 1903–1924	47	19	
	923	1,289	0.72:1

TABLE 4 (continued)

	Males	Females	Ratio
DUODENAL ULCER			
Adults			
Willigk, 1856	3	3	
Smith, 1910	97	16	
Friedenwald, 1912	307	222	
Adams and Cassidy, 1913	41	6	
Wulff, 1917	29	10	
Rovsing, 1920	117	47	
Haberer, 1920	11	4	
The Mayo Clinic, 1915–1921	7,023	2,023	3.47:1
Beck, 1923	82	10	
Moynihan, 1923	433	98	4.4:1
Sherren, 1920, 1924	638	130	4.9:1
Wilkie, 1924	33	8	4.1:1
Eiselsberg, 1925	400	68	5.9:1
U. S. Mortality Statistics, 1925	1,333	368	3.6:1
Walton, 1925, 1928	344	73	4.7:1
Lewisohn and Ginzburg, 1926	64	5	
Martin and Sutherland, 1926	149	27	
Wilson (Martin, Sutherland, 1926)	172	65	
Sturtevant and Shapiro, 1926	34	10	
Hauser, 1926	193	103	1.9:1
Kohiyer (Günther, 1927)	85	15	
Chvostek (Günther, 1927)	44	17	
Collin (Günther, 1927)	205	52	
Melchior (Günther, 1927)	503	116	
Hart (Günther, 1927)	16	6	
Gatewood *et al.*, 1928	30	9	
Louria, 1928	147	19	5.7:1
Broster, 1928	104	27	
Smith, 1928	98	80	
Miller *et al.*, 1929	188	33	
	12,923	3,670	3.52:1
Children			
Collected	57	54	1.1:1

TABLE 4 (continued)

	Males	Females	Ratio
PERFORATED DUODENAL ULCER			
Dickinson, 1894	14	3	
Brunner, 1903	74	8	
Petren, 1911	16	2	
Caird *et al.*, 1913	179	21	8.5:1
Sullivan, 1916	14	1	
Scully, 1918	11		
Wood, 1918	9	1	
Rovsing, 1920	12		
McKelvey, 1921	18	1	
Bullock, 1921	29	1	
Prader, 1922	19		
Schmidt, 1922	9	1	
Gibson, 1923	37	1	
Speck, 1923	62	15	
Bolens, 1924	6		
Powers, 1925	4		
Pollok, 1926	12	3	
Johnston, 1926	14		
Robbins, 1926	14	1	
Rolleston, 1926	3	3	
Hauser, 1926	27	5	
Brenner, 1927	25	2	
Hinton, 1928	12		
Bager, 1929	881	184	4.8:1
Collected, 1903–1927	21	1	
	1,522	254	6.0:1
"PEPTIC ULCER" (NOT LOCALIZED DEFINITELY)			
Friedenwald, 1912	676	324	2.1:1
Agote, 1916	309	81	
Dowden, 1916	277	148	
Baetjer and Friedenwald, 1918	279	229	
Johnson, 1918	30	20	
Mayo, 1921	4,292	1,431	3.0:1
Wilson, 1926	497	193	2.6:1
Fishbaugh, 1927	139	61	
Martin, 1928	23	1	
	6,522	2,488	2.62:1

TABLE 4 (continued)

	Males	Females	Ratio
PERFORATED "PEPTIC ULCER" (PROBABLY MAINLY DUODENAL ULCER)			
Simon, 1913	9	5	
Pantry, 1916	25	2	
Connors, 1916	10		
Kelly, 1917	36	6	
Demmer, 1918	49	3	
Wood, 1918	11	9	
Stewart and Barber, 1922	20	4	
Schmidt, 1922	15	4	
Stokes, 1923	14	1	
Steichele, 1923	40	13	
Engelsing, 1924	37	1	
McCreery, 1924	24	1	
Van Amstel, 1925	40	93	
Hertz (Schwarz, 1925)	43	17	
Bruett (Schwarz, 1925)	135	30	4.5:1
Mills, 1925	38	2	
Cuendet, 1925	23	4	
McGlannan and Bongardt, 1926	27	1	
Dunbar, 1926	355	32	11.1:1
Kunz, 1926	50	4	
Evans, 1926	12		
Muehsam, 1926	98	18	
Meyer and Abrams, 1926	62		
Meyer (Günther, 1927)	30	8	
Hayter, 1927	23	4	
Stenbuch, 1927	86	2	
Smith, 1928	3	3	
Gibson, 1928	118	5	23.6:1
Wolfson and Gray, 1929	27		
Brown, 1929	95	5	
Collected, 1919–1924	13		
	1,568	277	5.66:1
GASTROJEJUNAL AND JEJUNAL ULCERS			
Wright, 1918	113	27	4.2:1
Lewisohn, 1921	17	1	
Chiari, 1925	15	2	
Walton, 1925	19	1	
Balfour, 1926	248	22	11.3:1
Winkelbauer, 1926	9	3	
Urrutia, 1927	31	4	
Hurst and Stewart, 1928	59	6	9.8:1
Collected, 1904–1928	17	7	
	528	73	7.2:1

TABLE 4 (continued)

	Males	Females	Ratio
PERFORATED GASTROJEJUNAL ULCERS (INTO PERITONEAL CAVITY)			
Lieblein, 1917	2	3	
Ashcroft, 1926	2		
Leveuf, 1927	25	7	
Bager, 1929	24	7	
Collected, 1921–1926	8		
	61	17	3.6:1
GASTROCOLIC AND JEJUNOCOLIC FISTULA			
Verbrugge, 1925	215	1	
Brenner, 1927	1		
Monroe and Emery, 1928	2		
Rowlands, 1928	1		
	219	1	219:1
HOUR-GLASS STOMACH			
Watson, 1900	4	41	
Moynihan, 1908	7	15	
Hurst and Rowlands, 1921	4	41	
Thomas, 1921	4	46	
Sherren, 1924	12	102	0.1:1
Mayo, 1925	52	107	0.5:1
Hauser, 1926	7	44	
Günther, 1927	26	134	
Walton, 1928	1	19	0.05:1
Collected, 1902–1921	1	5	
	118	554	0.2:1

As will be seen from table 4, the ratio of men to women operated on for gastric ulcer at The Mayo Clinic in the nineteen years from 1910 to 1928 inclusive is $3.25 \pm 0.10:1$. This ratio is larger than the 2.5:1 for the United States mortality statistics (1925); it is larger than the 1.6:1 for two groups of patients operated on for ulcer in England, and it is larger than the 1.9:1 recently (1919–1924) reported from Germany.

Perhaps in America there is something about the strenuous life which leads to the formation of peptic ulcer in men. This is suggested by the fact that at The Mayo Clinic there has in recent years been a gradual increase in the number of men as compared with the number of women operated on for gastric ulcer. As will be seen from Figure 1 the ratio has increased irregularly from 1.4:1 in 1913 to 6.7:1 in 1927 and 3.9:1 in 1928. Against the proposed strenuous life theory of causation of ulcer, however, is the fact that there has been no corresponding increase year by year in the ratios for duodenal ulcer. There

has been a slight upward trend since 1917 but the ratio today is no higher than it was in 1910, and in the years from 1910 to 1917 there was a gradual decrease from 4.9:1 to 2.5:1.

In Germany also during the last ten years there appears to have been a big change in the sex incidence of so-called gastric ulcer. Günther (1927, xl, 110) gives for the years from 1902 to 1910 an average ratio (men to women) of 0.3:1, and for the years from 1911 to 1924, 2:1. In the medical clinic at Leipzig the ratio has varied somewhat as it has done at The Mayo Clinic. In the years from 1919 to 1925 the figures were 1.2, 1.6, 2.3, 2.7, 1.1, 3.6, and 2.1:1.

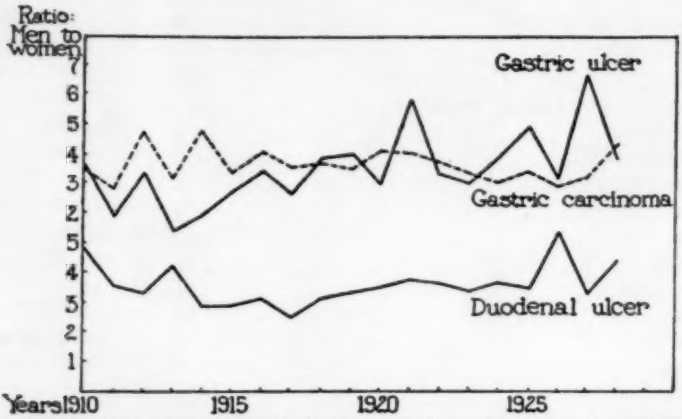

FIG. 1. This chart shows yearly trends in the sex ratio (men to women of patients operated on at The Mayo Clinic for gastric and duodenal ulcer and gastric carcinoma.

Gastric ulcers appear to perforate acutely somewhat more frequently in women than in men. An analysis made in 1908 showed that this was true even at The Mayo Clinic, where so few women are seen with gastric ulcer. This point deserves more careful study because duodenal ulcers appear to perforate acutely six times as frequently in men as in women. Possibly the greater amount of strenuous physical exertion in men may have a marked influence on ulcers situated at the "hook of the hammock": the point at which the movable stomach is connected with the fixed duodenum.

Statistics from Europe and America show that everywhere duodenal ulcer is found about three and a half times as frequently in men as in women. Taking the figures from The Mayo Clinic for the years from 1910 to 1928 inclusive, the ratio of men to women is 3.50 ± 0.7:1.

Strange to say duodenitis has so far been found with equal frequency in men and women. That the susceptibility of men to the formation of ulcers is acquired and due to some activity or habit or internal secretion is indicated by the fact that in children, ulcers in both stomach and duodenum have been found with about equal frequency in the two sexes. In the cases collected by us from the literature the ratio for gastric ulcer was 0.7:1 and for duodenal 1.1:1.

Some of the most remarkable sex ratios encountered in this study are those for gastrojejunal and jejunal ulcers. Almost everyone who has studied these ulcers has found them much more frequently in men. Balfour reported a ratio of 11.3:1; Lewisohn, 17:1; and Walton, 19:1. So far as we know no inkling has been obtained as to the cause of this tremendous difference. Even more remarkable is the sex incidence of gastrojejunocolic fistulas. For some unknown reason they occur almost always in men, and the ratio of 219:1 cries aloud for an explanation.

Still another remarkable feature about gastric ulcer is that when it produces hour-glass deformity of the stomach it generally does so in women. Some of the English writers have been particularly impressed with this peculiarity. Sherren gives a ratio (men to women) of 0.1:1, Walton gives 0.05:1, and Mayo, 0.5:1. These figures are all the more surprising in view of the fact that gastric ulcer is so seldom seen in women.

CARCINOMA OF THE STOMACH

The sex incidence of carcinoma of the stomach varies in different parts of the world, but most investigators have found the disease to be more common in men. The ratio of men to women operated on at The Mayo Clinic in the years from 1910 to 1928 inclusive is 3.54 ± 0.10:1. The close agreement between this ratio and that for gastric ulcer (in The Mayo Clinic) is interesting when taken in connection with the fact that in many cases gastric carcinoma appears to develop in the wall of a gastric ulcer. Somewhat against the theory that carcinoma generally arises in ulcers is the fact, recorded in figure 1, that while at The Mayo Clinic from 1913 to 1928 the incidence of gastric ulcer in men as compared with that in women has been increasing, the corresponding ratio for carcinoma of the stomach has remained practically constant.

TABLE 5

Carcinoma of the Digestive Tract

	Males	Females	Ratio
MALIGNANT TUMORS OF THE SALIVARY GLANDS			
Kaufmann, 1881	33	31	
Kennon, 1921	15	10	
Wakeley, 1929	7	5	
	55	46	1.2:1
CARCINOMA OF THE TONSIL			
Matthews, 1911	30	2	
EPITHELIOMA OF THE LIP			
Wörner, 1886	275	30	9.2:1
Broders, 1920	526	11	47.7:1
MacFarland, 1924 (deaths)	647	74	8.7:1
	1,448	115	12.6:1
EPITHELIOMA OF THE TONGUE			
Power, 1918 (deaths)	6,257	782	8.00:1
Turner, 1920	16	2	
Bloodgood, 1921	265	45	
Judd and New, 1923	262	41	
MacFarland, 1924 (deaths)	2,124	271	7.84:1
Evans and Cade, 1927	16	1	
	8,940	1,142	7.83:1
MALIGNANT TUMORS OF THE ESOPHAGUS			
Schmidt, 1897	584	188	
Lamy, 1910	114	20	
Hunziker, 1914	3,447	590	5.84:1
Turner, 1920	30	12	
Petri (Bensaude, Rivet, 1923)	41	3	
Vinson, 1923	127	27	4.7:1
MacFarland, 1924 (deaths)	2,358	852	
Frief *et al.* (Luedin, 1926)	1,015	139	
Andreson, 1927	31	7	
Blauwkuip (Friedenwald, 1927)	112	13	
Buchbinder (Friedenwald, 1927)	135	10	
Souttar, 1927 (deaths)	12,139	3,870	3.13:1
Friedenwald *et al.*, 1927	106	22	
Sherman, 1928	46	4	
	20,285	5,757	3.52:1

TABLE 5 (continued)

	Males	Females	Ratio	
CARCINOMA OF THE STOMACH				
Willigk, 1856	83	86		
Fox, 1872	680	623	1.1:1	
MacRae (Osler, 1906)	126	24	5.3:1	
Creite, 1908	58	47		
Friedenwald, 1914	588	412		
Smithies and Ochsner, 1916	693	228	3.0:1	
Mathieu (Noir, Lafont, 1923)	387	188		
MacFarland, 1924 (deaths)	8,369	8,355	1.0:1	
Stewart, 1925	113	52		
Freeman and Flinn, 1925	252	63		
Balfour and Hargis, 1926	790	210	3.8:1	
Günther, 1927	251	180		
Warwick, 1928	143	33		
	12,533	10,501		1.19:1
CARCINOMA OF THE INTESTINE (SMALL AND LARGE)				
MacFarland, 1924 (deaths)	6,312	6,731	0.9:1	
Leichtenstern (Günther, 1927)	72	47		
	6,384	6,778		0.94:1
CARCINOMA OF THE SMALL INTESTINE				
Perry and Shaw, 1893	8	5		
Schlieps, 1908	28	12		
Soper, 1909	6	6		
Craig, 1924	29	7	4.1:1	
Eusterman and Berkman, 1925	12	3		
Collected	18	6		
	101	39		2.6:1
CARCINOMA OF THE LARGE INTESTINE				
Edwards, 1894	542	233	2.3:1	
Hartwell, 1905	26	20		
Smith, 1909	24	16		
Lynch, 1915	281	210	1.3:1	
Wells, 1920	26	27		
Russell, 1921	24	23		
Craig, 1923	66	34		
Buie, 1923	1,317	620	2.12:1	
Günther, 1927	18	13		
	2,324	1,196		1.94:1
PRIMARY CARCINOMA OF THE LIVER				
Griffith, 1917	25	26		
Eggel (Günther, 1927)	98	57		
Collected	14	5		
	137	88		1.6:1

TABLE 5 (continued)

	Males	Females	Ratio
CARCINOMA OF THE EXTRA-HEPATIC BILE DUCTS			
Musser, 1889	9	9	
Schultze, 1900	12	5	
Miodowski, 1902	26	4	
Sherrill, 1906	1	1	
Rolleston, 1914	50	35	
Rolleston, 1914	14	5	
	112	59	1.9:1
CARCINOMA OF THE GALLBLADDER			
Musser, 1889	23	75	
Siegert, 1896	14	79	
Fütterer, 1901	52	204	0.3:1
Sherrill, 1906	1	1	
Terrier and Auvray (Rolleston, 1914)	10	40	
Winton (Rolleston, 1914)	17	43	
Renshaw, 1921, 1922	16	68	
	133	510	0.3:1
CARCINOMA OF THE PANCREAS			
Da Costa, 1858	24	13	
Ancelet, 1864	102	59	1.7:1
Boldt, 1882	35	21	
Mirallie, 1893	69	37	
Rosenfeld, 1904	2	1	
Futcher, 1919	22	9	
Mussey, 1919	72	18	
Speed, 1920	36	16	
Eusterman, 1922	35	13	
Bashford (Opie, 1926)	526	474	1.1:1
Kiefer, 1927	18	15	
Friedenwald and Cullen, 1928	25	12	
	966	688	1.4:1

Linitis plastica, which can usually be shown to be a form of carcinoma of the stomach, occurs about twice as frequently in men as in women.

CARCINOMA OF THE DIGESTIVE TRACT, EXCEPTING THE STOMACH

A number of interesting questions arise when one comes to study the data presented in table 5. It will be noted that malignant tumors of the salivary glands occur with equal frequency in the two sexes. As is well known, epithelioma of the lip occurs many times as frequently in men as in women. In Broders' large series the ratio was

48:1. This is doubtless due often to the influence of the hot pipe-stem on the lip, but possibly the hot smoke has some effect, because carcinoma of the tonsil is seen fifteen times as frequently in men as in women, and epithelioma of the tongue is seen eight times as frequently in men. With carcinoma of the esophagus, where tobacco smoke probably has no influence, the ratio (men to women) is similar to that for carcinoma of the stomach.

Carcinoma of the small and large bowel appears from two to four times as frequently in men as in women. Primary carcinoma of the liver is seen somewhat more frequently in men than in women, and carcinoma of the extra-hepatic bile ducts is about twice as common in men as in women. As one would expect, carcinoma of the gall-bladder is seen four times as often in women as in men. Carcinoma of the pancreas occurs only slightly more frequently in men than in women.

TABLE 6

Sarcoma of the Digestive Tract

	Males	Females	Ratio
SARCOMA OF THE TONSIL			
Matthews, 1911	66	21	3.1:1
SARCOMA OF THE ESOPHAGUS			
Orton, 1924	31	10	3.1:1
SARCOMA OF THE STOMACH			
Ziesche and Davidsohn, 1909	59	57	
Flebbe, 1913	77	70	
Haggard, 1920	33	33	
Broders and Mahle, 1921	11	1	11:1
Collected, 1906–1927	25	15	
	205	176	
With duplications eliminated	136	111	1.2:1
SARCOMA OF THE APPENDIX			
Harte, 1908; Stewart, 1908	5	2	
SARCOMA OF THE INTESTINE			
Perry and Shaw, 1893	2	9	
Siegel (Günther, 1927)	31	6	
Collected, 1907–1910	2		
Rankin and Chumley, 1929	13	5	
	48	20	2.4:1
PRIMARY RETROPERITONEAL SARCOMA			
Andrews, 1923	23	5	4.6:1

SARCOMA OF THE DIGESTIVE TRACT

As will be seen from table 6, sarcoma of the digestive tract appears more frequently in men than in women. Strange to say the sex ratio for sarcoma of the tonsil is much lower than that for carcinoma of the same organ. The situation in regard to sarcoma of the stomach is puzzling. At The Mayo Clinic the ratio for cases observed up to 1921 is 11:1; elsewhere it appears to be 1.1:1.

BENIGN TUMORS OF THE DIGESTIVE TRACT

It is a curious fact that a number of the benign tumors, especially those about the omentum, mesentery, and peritoneum, occur more frequently in women than in men (Table 7). Carcinoid tumors of the appendix also occur somewhat more frequently in women than in men. The ratios given by different authors are probably all affected by the fact that so many appendixes are removed during operations on the pelvic organs in women. We find that at The Mayo Clinic in 1928, 184 persons were operated on for acute appendicitis. Ninety-

TABLE 7

Benign Tumors of the Digestive Tract

	Males	Females	Ratio
MIXED TUMORS OF THE SALIVARY GLANDS			
Wood, 1904	25	19	
Eisenmerger (Bourgois, Lenormant, 1909)	37	39	
New, 1920	33	35	
Sistrunk, 1921	56	56	
Fry, 1927	11	14	
	162	163	1:1
BENIGN TUMORS OF THE STOMACH			
Brunn and Pearl, 1926	34	27	
Balfour and Henderson, 1927	35	23	
Collected, 1921–1928	1	2	
	70	52	1.3:1
ENDOTHELIOMA OF THE OMENTUM			
Hasbrouch, 1908	6	14	0.4:1
BENIGN TUMORS OF THE MESENTERY			
Bowers, 1906	6	18	
Collected		2	
	6	20	0.3:1

TABLE 7 (continued)

	Males	Females	Ratio
CYSTS OF THE MESENTERY			
Brinsmade, 1908	20	21	
Deaver, 1909	15	24	
Coley, 1910	1		
	36	45	0.8:1
BENIGN TUMORS OF THE PERITONEUM			
Freer (Rolleston, 1926)		11	
Whitney (Rolleston, 1926)	4	15	
Wahlendorf (Rolleston, 1926)	28	72	
	32	98	0.3:1
PANCREATIC CYST			
Fitz, 1900	2	8	
Coombs and Nash, 1901	11	18	
Koerte (Osler, 1906)	60	56	
Judd, 1921	17	24	
	90	106	0.8:1
CARCINOID TUMOR OF THE APPENDIX			
Jackson, 1923	106	211	
Selinger, 1929	6	28	
	112	239	0.5:1

four were men and ninety were women. Five hundred and fifty-six were operated on for subacute and chronic appendicitis, and among them the ratio of men to women was 0.8:1. In addition 1,274 appendixes were removed during the course of operations on some other organ. In this group of patients the ratio of men to women was 0.6:1. During the year, then 2,014 appendixes were removed, and for all the patients submitting to appendectomy the ratio of men to women was 0.7:1. The true sex ratio, therefore, for patients with carcinoid tumors of the appendix is not 0.5:1, as would at first appear, but more nearly 0.7:1.

Mixed tumors of the salivary glands appear with equal frequency in the two sexes. Benign tumors of the stomach appear slightly more frequently in men than in women.

MISCELLANEOUS DISEASES OF THE DIGESTIVE TRACT

As will be seen from table 8 sialolithiasis occurs three times as frequently in men as in women. The sex incidence of cardiospasm varies considerably according to the reports of different observers, possibly because some include cases of mild spasm due to cholecystitis.

Vinson, at The Mayo Clinic, found true cardiospasm slightly more often in men than in women. Achylia gastrica appears to affect men and women with about equal frequency.

TABLE 8

Miscellaneous Diseases of the Digestive Tract

	Males	Females	Ratio
SIALOLITHIASIS			
Günther, 1927	217	67	3.2:1
CARDIOSPASM			
Plummer, 1908	18	22	
Einhorn and Meyer, 1910	8	7	
Thieding, 1921	177	91	1.9:1
Smithies, 1921	22	25	
Bensaude and Rivet, 1923	5	2	
Verbrycke (Friedenwald, 1926)	30	61	
Vinson, 1926	294	206	1.4:1
Soper and Cassidy, 1928	3	12	
	557	426	1.3:1
ACHYLIA GASTRICA			
White, 1906	9		
Sailer, 1922	21	37	
Friedenwald, 1926	55	57	
Friedenwald and Morrison, 1926	36	64	
Wright, 1928	56	60	
Lichty, 1929	152	192	
	329	410	0.8:1
DIVERTICULOSIS OF THE DUODENUM			
Wilkie, 1913	19	10	
Spriggs, 1920	7	3	
Morrison and Feldman, 1925	8	4	
Hartung, 1925	5	2	
	39	19	2.1:1
DIVERTICULOSIS OF THE SMALL INTESTINE			
Case, 1920	72	74	
Collected	14	18	
	86	92	0.9:1
DIVERTICULOSIS OF THE COLON			
Telling, 1908	53	28	
Judd and Pollock, 1924	84	34	
Peck, 1925	30	6	
Collected	12	2	
	179	70	2.6:1

TABLE 8 (continued)

	Males	Females	Ratio
INTESTINAL OBSTRUCTION			
Finney, 1906	16	8	
Stockton and Richardson, 1920	67	47	
Gibson, 1920	472	410	
U. S. Mortality statistics, 1925 (acute obstruction)	3,452	3,505	0.99:1
Leichtenstern (Günther, 1927)	808	461	
	4,815	4,431	1.09:1
INTESTINAL POLYPOSIS			
Bokai, 1871	16	9	
Bokay, 1913	4	4	
Bodenhamer (Günther, 1927)	30	45	
Thorbecke (Günther, 1927)	100	67	
Saint, 1927	41	15	
Hullsiek, 1928	52	46	
Collected, 1913–1920	5	2	
	248	188	1.3:1
VOLVULUS			
Gibson, 1900	67	40	
Kuhn, 1902	73	22	
Corner and Sargent, 1905	42	13	
Fitz (Osler, 1906)	29	13	
Power, 1916	14	11	
Ophüls, 1926	4		
	229	99	2.3:1
INTUSSUSCEPTION			
Adults			
Thomson, Haven, Duchaussoy, Hansen — Pilz, 1870	20	14	
	34	10	
	49	14	
	82	43	
	185	81	2.3:1
Children			
Rilliet, Hansen, Smith, Pilz — Pilz, 1870	22	3	
	42	13	
	22	10	
	72	39	
	158	65	2.4:1

TABLE 8 (continued)

	Males	Females	Ratio
Practically All Children			
Leichtenstern, 1874	381	212	1.8:1
Hirschsprung, 1894	14	4	
Gibson, 1897	82	49	
Wallace, 1905	12	8	
Fagge, 1905	12	6	
Fitz (Osler, 1906)	52	27	
Fitzwilliams, 1908	536	252	2.1:1
Clogg, 1908	11	5	
Adams, 1910	66	34	
Brown, 1925	21	11	
Cohen, 1927	15	7	
Fromme (Günther, 1927)	21	11	
Burghard, 1928	511	250	2.0:1
Edberg, 1928	25	12	
Collected, 1884–1917	16	9	
	1,779	899	1.98:1
TORSION OF OMENTUM WITHOUT ADHESIONS			
McWhorter, 1928	18	6	3.0:1
MESENTERIC EMBOLISM AND THROMBOSIS			
Osler, 1906	137	77	1.8:1
EMBOLISM AND THROMBOSIS OF PORTAL SYSTEM			
Wilkins, 1923	25	10	2.5:1

Most forms of acute intestinal obstruction occur with equal frequency in men and women. Volvulus of the bowel has been reported 2.3 times as often in men as in women. Intussusception, which is largely a disease of children, occurs about twice as frequently in boys as in girls. The sex ratio is the same when the accident happens in adults. Mesenteric embolism and thrombosis occur about twice as frequently in men as in women.

COMMENT

At the present time little can probably be gained by theorizing about the difference in sex incidence here described. Our main hope is that others, aroused perhaps by the contemplation of the figures presented, will begin to gather new data so carefully that clearer light will be thrown on the etiology of the diseases under discussion. One thing that the figures have done for us is to shake our previously

acquired belief that most or all of the increase in susceptibility of men to disease is due to a more active life. The fact that even the congenital defects are found more often in males than in females shows that there is some inborn peculiarity about many of the tissues of boys which predisposes them to attack by disease.

In view of the fact that the sex incidence of some diseases varies so markedly from city to city we have thought it wise to bring together in one place in table 9 all the ratios which have been published from The Mayo Clinic. They are particularly valuable in that they are all based on cases sampled from one mass of material.

TABLE 9

Data from The Mayo Clinic

		Males	Females	Ratio
New, 1920	Mixed tumors of the salivary glands	33	35	
Sistrunk, 1921		56	56	
		89	91	0.98:1
Broders, 1920	Epithelioma of the lip	526	11	48:1
New, 1918	Carcinoma of the jaws and cheeks	19	2	9.5:1
Broders, 1924	Carcinoma of the cavities and internal organs of the head and neck	322	40	8.1:1
Judd and New, 1923	Epithelioma of the tongue	262	41	6.4:1
Vinson, 1925	Diverticulum of the esophagus	31	4	7.8:1
Plummer, 1908	Cardiospasm	18	22	
Vinson, 1926		294	206	
		312	228	1.4:1
Vinson, 1923	Carcinoma of the esophagus	127	27	4.7:1
Moore and Aurelius, 1928	Syphilis of the stomach	60	27	2.2:1
Operative cases, 1910 to 1928 inclusive	Ulcer of the stomach	1,564	482	3.25 ± 0.10:1
Mayo, 1908	Acute perforated ulcer of the stomach	40	47	0.9:1
Operative cases, 1910 to 1928 inclusive	Ulcer of the duodenum	8,112	2,312	3.5 ± 0.07:1
Nagel, 1926	Duodenitis	12	14	0.9:1
Balfour, 1926	Gastrojejunal and jejunal ulcers	248	22	11.3:1

TABLE 9 (continued)

		Males	Females	Ratio
Verbrugge, 1925	Gastrocolic and jejunocolic fistula	21		
Mayo, 1925	Hour-glass stomach	52	107	0.5:1
Mayo, 1925	Hour-glass duodenum	20	8	2.5:1
Balfour and Henderson, 1927	Benign tumors of the stomach	35	23	1.5:1
Operative cases, 1910 to 1928 inclusive	Carcinoma of the stomach	3,018	852	3.54 ± 0.10:1
Broders and Mahle, 1921	Sarcoma of the stomach	11	1	11:1
Eusterman, 1924	Cholecystitis	1,394	3,584	0.38:1
Operative cases 1890 to 1929				
Under fifteen years		1	5	0.2:1
Fifteen to nineteen years (nulliparous)		9	54	0.2:1
Eusterman, 1924	Cholelithiasis	2,188	6,927	0.32:1
Operative cases, 1890 to 1929				
Under fifteen years		1	5	0.2:1
Fifteen to nineteen years (nulliparous)		9	54	0.2:1
Renshaw, 1921, 1922	Carcinoma of the gallbladder	16	68	0.2:1
Judd and Burden, 1925	Internal biliary fistula	42	111	0.4:1
Judd, 1921	Cyst of the pancreas	17	24	0.7:1
Mussey, 1919	Carcinoma of the pancreas	72	18	
Eusterman, 1922		35	13	
		107	31	3.8:1
Sistrunk, 1921	Calculus of the pancreas	1	3	
Hartman, 1925		2	2	
		3	5	0.6:1
MacCarty and McGrath, 1914	Carcinoid tumor of the appendix	11	26	
Jackson, 1923		8	16	
		19	42	0.5:1
Lemon, 1923	Tuberculous enteritis	34	16	2.1:1
Bargen, 1927	Chronic ulcerative colitis	114	86	1.3:1
Judd and Thompson, 1928	Hirschsprung's disease	42	15	2.8:1
Judd and Pollock, 1924	Intestinal diverticulosis	84	34	2.5:1

TABLE 9 (continued)

		Males	Females	Ratio
Saint, 1927	Intestinal polyposis	41	15	2.7:1
Craig, 1924	Carcinoma of the small intestine	29	7	
Eusterman and Berkman, 1925		12	3	
		41	10	4.1:1
Craig, 1923	Carcinoma of the large intestine	66	34	
Buie, 1923		1,317	620	
		1,383	654	2.12:1
Rankin and Chumley, 1929	Sarcoma of the large intestine	13	5	2.6:1
Mayo, 1921	Tuberculous peritonitis	42	153	0.3:1
Andrews, 1923	Primary retroperitoneal sarcoma	23	5	4.6:1

SUMMARY

Hundreds of articles have been reviewed in an effort to throw light on the comparative frequency with which various gastro-intestinal diseases affect men and women. The ratios vary in different clinics and at different times.

Most of the diseases of the digestive tract occur more frequently in men than in women, but a few, such as those of the gallbladder, attack women more often than men. Data are presented which show that pregnancy is not such an important factor in producing cholelithiasis as it has always been thought to be.

High ratios (men to women) are found in the case of carcinoma of the lip, of the tongue, and of the tonsil; in the case of gastrojejunal ulcer, and particularly in the case of gastro-colic fistula. Women are unusually subject to gallbladder disease, to hour-glass stomach, and to benign tumors of the peritoneum. It is a curious fact that the sex ratios for congenital pyloric stenosis and for Hirschsprung's disease of the colon are about the same as those for peptic ulcer in adults.

At The Mayo Clinic between the years 1913 and 1927 there has been a gradual increase in the sex ratio (men to women) for gastric ulcer. The figures vary from 1.4:1 to 6.7:1. During the same interval the corresponding ratios for carcinoma of the stomach and for duodenal ulcer have remained fairly constant.

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A CRITIQUE OF PROFESSOR FREDERIC WOOD-JONES'S PAPER: "SOME LANDMARKS IN THE PHYLOGENY OF THE PRIMATES"

BY WILLIAM K. GREGORY

In a series of papers extending now over many years, Professor Wood-Jones has set forth his reasons for inferring that man originated, not from the stem of the anthropoid apes, but from a largely extinct group of Primates that is represented today only by *Tarsius*. In the May 1929 number of HUMAN BIOLOGY he gives an exceedingly clear and compact exposition of some of the chief points in favor of this hypothesis; at the same time he attempts to trace the main branches of the Primates chiefly according to the various arrangements and contacts of the bones on the side wall of the cranium and in the floor of the orbit. For example, the alisphenoid-parietal articulation is characteristic of primitive mammals, of the tree-shrew-lemur phylum and of the *Tarsius*-man series; it is also found in a somewhat reduced condition in the American monkeys, and it occurs to a variable extent in the Asiatic monkeys and Asiatic anthropoid apes; the opposite arrangement, namely the fronto-temporal articulation, is characteristic only of the African monkeys and African anthropoid apes, but it occurs occasionally in other groups. This leading contact character is taken in combination with several other contact characters, namely the presence or absence of the lacrymo-ethmoidal contact in the inner wall of the orbit, the presence or absence of descending flanges of the frontal in the floor and side walls of the anterior cranial fossa, which if present cover the underlying presphenoid-mesethmoid contact; the presence or absence of a jugal-parietal articulation; in addition to these the author selects for consideration the different relations of the tympanic bone to the auditory bulla and the presence or absence of a foramen for the carotid artery in the wall of the bulla. In the case of each pair of contrasting characters the author attempts to show which of the two is the older; in certain cases he also attempts to expose the "causal factor" that has compelled one character to give way to its opposite. His chief phylogenetic conclusions based upon

the consideration of the foregoing material may be outlined as follows: The tree-shrews belong in a phylum that culminates in the recent and fossil lemurs; this phylum, the Strepsirhini, is entirely independent of the Haplorhini, or Tarsier-Monkey phylum, which includes all the rest of the primates. Of the Haplorhini, the oldest branch is the Tarsioid-Man series, including the Eocene tarsioids, their slightly modified descendant the living *Tarsius*, and man, as the "surviving member of the giant progeny of the unspecialized Tarsioids of the Eocene." The Platyrhini, or American monkeys, constitute an early side branch of the primitive tarsioid stock. After the line leading to man had been given off, the Old World tarsioids gave rise to several successive pithecoid offshoots characterized by the loss of the "Tarsioid simplicity" in the architecture of the skull and by the assumption of the more specialized of the characters listed above. Of these, the "Asiatic Pithecus Gibbon stock" was the first to be given off and it culminated in the gibbons and the orang; these, says our author, were

> still hopelessly clinging to a specialized arboreal life, but retaining some of their birthright of Tarsioid simplicity. The most specialized group—the least primitive by far—was also subjected to the same influences and begot the Chimpanzee and Gorilla as divergences from the *Cerocopithecus*-Baboon stem. That the giant offshoots of all the groups show several convergent likenesses to each other is only to be expected, but these convergent likenesses must be assessed at their true value and must not be taken as evidences of kinship or ancestry.

During a recent long ocean voyage I have availed myself of the opportunity of studying this paper with the greatest interest, partly for the reason that if the results cited above are well founded, many of my own published findings concerning the evolution of the primates must be erroneous.

As early as 1699 Tyson in his immortal work on the anatomy of a "Pygmie" (which was really a chimpanzee), noted that in the majority of its anatomical characters the "pygmie" was nearer to man than it was to a monkey. "The methods of Edward Tyson," says Wood-Jones, "are still followed: a number of striking resemblances between the two groups [the African anthropoids and man] far outweighs, in the opinion of most authorities, the few, apparently trifling, differences that may be discovered. The methods of Tyson are valid enough, if due weight is accorded to the differences and if all the characters employed in the comparison are assessed at their proper value. The only question to be decided is the matter of assessing the value

of the characters." Professor Wood-Jones will therefore not be surprised if other anatomists continue to assess at far lower values the differences in sutural contacts and patterns observed in the skulls of different types of Primates, upon which differences he chiefly relies in deciphering the supposed history of the several phyla. For, in the first place, in comparing related forms such as man and chimpanzee the value of a small number of differences does indeed appear to diminish when the number of agreements discovered to exist between the forms compared becomes very large and especially when these anatomical agreements are not limited to any particular region but are "all pervasive" throughout the two organisms compared. Secondly, certain of the characters upon which he relies are not constant but more or less variable and of doubtful chronological status. Thirdly, his analysis of the supposed causal factors involved in the various contrasts noted above appears unsatisfying and incomplete. Finally, I think it may be shown that his deductions based on these variable characters are not in accordance with the evidence from other sources.

HERITAGE AND HABITUS

Nor can I follow him unreservedly in his practical applications of the principle that "it is necessary to recognize the fundamental structural features due to heritage; it is necessary to assess the structural factors due to habitus and it is important to attempt to assign the proper causal factor to these last characters." Apparently Wood-Jones is here using the terms "heritage" and "habitus" in the sense in which they were defined in my work *The Orders of Mammals* in 1910; but in assessing the phylogenetic value of the fronto-temporal and other articulations he appears to have overlooked the possibility that in practice a complete clear-cut separation of "habitus" characters from "heritage" characters may sometimes be difficult. When we are studying a long and many-branched evolutionary series, some of the habitus acquired by a remote ancestor usually becomes the heritage of its diversified descendants. The adaptations of the skull to the enlargement of the eyes, once acquired as habitus characters by the early Primates, became heritage characters in some of their smaller-eyed descendants. In general the heritage of a given stage is by definition made up of the older characters, and the habitus of the newer characters; but as to any given character the available evidence may be insufficient for a satisfactory decision as to its exact relative age.

Again, the "causal factor" is seldom simple and ramifies in many directions that are hard to discover.

For example, it is difficult at present to be certain whether the fronto-temporal contact, which Wood-Jones tells us is found in some sixteen per cent or more of African negroes, is to be interpreted as a vanishing heritage character inherited from some African ape-like ancestor, or as an incipient habitus character in which these negroes are merely converging toward their African relatives. Even if we knew the relative frequency of this character in both foetal and adult skulls, we could scarcely be sure from that alone whether the character itself was declining or increasing, for the following reasons: (1) Some new human characters certainly originate in the foetal stages. Here may be cited the normal separation of the peroneus tertius from the parent muscle mass, as reported by Keith. (2) On the other hand, some old characters are not yet as much reduced in early foetal stages as they are in the adult (e. g., divergence of the great toe). (3) Certain new characters that become frequent in infantile stages may fail to be equally numerous in adult stages (e. g., blond hair in Europeans). Thus in regard to every variable character we will inquire: Is this a relatively new character that has not yet attained a universal distribution in the races of man, or is it the remnant of a once more widely distributed character that is now unstable and irregular? And when we compare foetal and adult stages of a character, if we rely implicitly on vague general "laws," such as the doctrines of Recapitulation and of the Irreversibility of Evolution, we shall run the risk of reading the record in the reverse direction so far as concerns some special character; for each case should be judged with reference to its very complex and shifting surroundings.

If we take the Simiidæ as a whole we find that the relationships of the bones around the pterion are distinctly variable; in the gibbon and orang the alisphenoid-parietal articulation frequently obtains, as in man; in the gorilla the opposite arrangement (fronto-temporal) is nearly, but not always, found and occasionally some orang skulls will show one contact on one side of the skull and its opposite on the other side (J. H. McGregor).

It seems highly likely that the "causal factor" in this case is more complex than our author supposes. The need for the enlargement of the skull to accommodate a rapidly increasing brain is the only factor he mentions, but several others appear to have claims for consideration. If we take a broad view of the patterns of the skulls

of recent and fossil amphibians, reptiles and mammals, we see that for one reason or another every element in the mosaic of skull patterns is constantly shifting, constantly trying, so to speak, to enlarge its own territory at the expense of its neighbors. The less successful, less aggressive elements often get crowded into small corners and finally disappear. Sometimes this apparent will to expand may be in response to increased stresses developed to resist the increasing pull of the jaw-, neck- or facial-muscles; sometimes the bone may retreat before an advancing nerve, brain mass or blood vessel; sometimes it may mold itself around an expansion of the tubo-tympanal canal. The increase in the bone may always depend upon an increasing blood supply. Again, if five bone centers (frontal, parietal, squamous, alisphenoid, jugal) all start to grow toward a shifting spot, the pterion, then the choice as to which three of the five will reach there first will depend upon the distance of each of these centers from the spot, the rates and directions of growth of the different regions of each bone and the amount of angular displacement due to the differential growth of the cranium and face, as well as perhaps other factors. Finally, the varying times in ontogeny at which each element enjoys its period of maximum growth must profoundly influence the results.

In the case of the forward extension of the squamous portion of the temporal, which in some forms finally makes a broad contact with the frontal, this may conceivably be correlated partly with an early anteroposterior expansion of the temporal region of the brain and it may be partly contingent upon the development of the tusk-like canines, large molars and powerful jaw muscles that are characteristic of catarrhine monkeys and African anthropoids. Similar stresses in the scaffolding or supporting elements might stimulate the downward growth of the reinforcing frontal flanges which appear on the inner wall of the orbit and on the floor of the cerebral fossa; also the same set of stresses might stimulate the upgrowth of the maxilla to meet the down-growing plates of the frontal.

There seems good reason to assume that the ancestral Old World primate had a relatively short stout jaw, a short face and strong scaffolding of the frontal, jugal and squamous regions. To one not committed in advance to extreme forms of the doctrine of irreversibility of evolution, it seems conceivable that after some or all of the contacts mentioned above were developed, there took place either a marked increase in brain-depth, as in man and orang, or a secondary reduction in the depth of the mandible, as in the gibbon, either of which made

possible the reduction of the fronto-temporal and fronto-maxillary articulations, the increase in the alisphenoid-parietal articulation and the exposure of the ethmoid in the weakened inner wall of the orbit.

Somewhat similar and somewhat different processes may have occurred in the *Tarsius* line but without for the moment assuming anything as to the degree of relationship between *Tarsius* and man, their net results may have been similar to those in man: the weakening of the jaws and concomitant enlargement of the eyes may have conditioned an exposure of the "*os planum*" in the orbit and a weak frontal process of the temporal; premature deepening of the brain may have produced an early expansion of the parietal, which may in this phylum have prevented the fronto-temporal articulation from forming; shortening of the face, enlargement of the eyes and forward growth of the temporal lobe of the brain seem to be the highly probable causes of the forward displacement of the alisphenoid, whose wing assumes a position more or less at right angles to its primitive position on the side wall of the cranium; the alisphenoid-jugal partition is a part of this complex.

Thus it appears to me that these supposed "landmarks in the Phylogeny of the Primates" may be less stable, reliable bases for triangulation than Wood-Jones takes them to be, and that the path of evolution may have been more devious than the broad and well-posted highway that he has constructed for it. In general it may often be true that "one fundamental structural difference begot of heritage outweighs many structural resemblances begot of habitus" (*op. cit*, p. 214), but with regard to each of the "landmarks" listed by Wood-Jones the real question appears to be, how fundamental is it, how far is it begot of heritage, and how far does it outweigh other structural resemblances, which may also be partly habitus and partly heritage characters?

THE TYPES OF PRIMATE SKULLS

To pass now to a consideration of certain of the types and subtypes of Primate skulls as defined by Wood-Jones and to their possible phylogenetic relationships, we may note that his "Type I, characteristic of the Tree-Shrews and Lemurs," is defined by the combination of six cranial characters Three of these, as Wood-Jones notes, are possessed by several primitive types of mammals (contact of lacrymal with orbital plate of palate bone, exposed contact of mesethmoid with presphenoid within the cranial cavity, alisphenoid broadly in

contact with parietal on side wall of braincase); of the remaining three (tympanic bone forming a ring, enclosed within the enlarged auditory bulla, foramen for entry of carotid artery into skull passing to one side of bulla, frontal and jugal entering into the formation of a postorbital bar) he considers that the relations of the tympanic bone constitute "a specialized feature," which is "confined to this phylum and cannot be regarded as in any way due to the varying demands of habitus." That it is a specialized feature as compared with the condition in more primitive mammals, few would be disposed to deny; but that it is not in any way due to the varying demands of habitus and that it did not give rise to the conditions observed in the typical primates, are both assumptions which may well be arguable. When we compare the auditory region of the very primitive Eocene lemuroids *Notharctus* and *Adapis* with those of more modernized primates, we see that their cavities are situated further laterally and posteriorly, while those of the American monkeys are drawn forward and inward. As the tympanic ring in both lemuroids and American monkeys is fastened to the bony arch between the post glenoid and posttympanic processes of the temporal bone, it may very well have retained this contact when the *cavum entotympanicum* was displaced forward and inward. Thus the latter would no longer overlap it but might, if reduced, even come to be overlapped by the expanded tympanic, as in the American monkeys.[1] In the existing African lemuroids the tympanic bone is no longer enclosed within the bulla, but few would argue that in general the auditory regions of *Galago* and *Nycticebus* are more primitive than those of *Notharctus* and *Adapis*.

Thus I can hardly follow Wood-Jones in definitely excluding the entire lemuroid phylum from ancestry to the earlier stocks of the true Primates, even though it includes many specialized lines, none of which may have been ancestral to the tarsioids and higher Primates. It is true that the earliest known lemuroids and tarsioids were already contemporaries in the Lower Eocene, but for all that, taking into consideration the skull, jaws and dentition, vertebræ, pelvis and limb bones, these Eocene lemuroids were on the whole vastly more primitive, more like ordinary mammals, than were the Eocene tarsioids; even the recent *Lemur* retains far more primitive mammalian characters in brain, placentation, and detailed branching of the carotid artery in the auditory region than those revealed in either *Tarsius* or any of the monkeys. It is also more like a primitive mammal in important

[1] This hypothesis is considered more fully in my memoir on *Notharctus*.

skeletal characters. And when we compare the six cranial characters which Wood-Jones assigns to "Type II, the Basal Type of skull of Tarsiers, Monkeys and Apes," we find that three of these characters are the same as in the tree-shrew-lemur type and each of the other three (exposure of the "*os planum*" of the ethmoid in the orbit, tympanic ring outside the cavity of the bulla, foramen for the entry of the carotid artery passing into the bulla) I regard as an advance upon the more primitive conditions observed in the ancient lemuroid *Notharctus*.

As to the position of the tree-shrews, in 1910 I gave an extended review of the evidence tending to show that they form the *structural* intermediates between the Primates and other orders of mammals, and many authors since then have brought forward additional evidence in the same direction. Nevertheless, the phyletic relationships of the Basal Eocene tree-shrews to the contemporary lemuroids is perhaps less close than to the contemporary tarsioids, as may be gleaned from the recent studies of Matthew, Teilhard and G. G. Simpson, and their precise phyletic relationships to the modern Menotyphla also remains to be cleared up. And in view of the truly annectant characters of *Rhynchocyon*, it seems arbitrary to leave the rest of the Menotyphla out of the Strepsirhine division of the Primates, if *Tupaia* itself is to go there.

DENTITION PATTERNS OF THE PRIMATES

As to the tarsioid phylum, which Wood-Jones takes as the starting-point for all the true Primates, it may indeed be such, or again it may not be. In all his discussions Wood-Jones leaves entirely out of account the evidence afforded by the dentition of fossil and recent Primates, possibly because he may class dentition with the habitus and therefore regard it as inferior in value to his "heritage" characters of cranial architecture. But in practice the patterns of the dentition are certainly no less characteristic than those of the cranial contacts favored by him, and vastly more is known about them in both fossil and recent skulls. Nearly all the known tarsioids are characterized by aberrant specializations of the incisors, which appear to remove them from the lines of ascent to the higher Primates. Most of them also have peculiar specializations of the molars which would operate in the same way. One, *Pseudoloris*, is quite close to, or even in the direct line of *Tarsius*, as shown by Teilhard de Chardin.

The *Necrolemur-Michochoerus* division has advanced in details in the construction of its upper molars to the quadritubercular type and in its lower molars to the quinquetubercular type, which are characteristic of the anthropoid-man division. These advances in the dentition are supplemented by several advances in skull-structure, but on the whole the Upper Eocene *Necrolemur* has not risen into the monkey grade and is undoubtedly still a specialized tarsioid, as shown in detail by Stehlin.

Quite different is the status of the little mandible from the Oligocene of Egypt, which constitutes the type and sole known specimen of *Parapithecus fraasi* Schlosser. So far as it goes, this appears to be intermediate between the tarsioid and the anthropoid-man series. It is assuredly a small Old World primate, in which the braincase must have been expanded transversely and the jaw shortened and pointed in front. The front teeth avoid the aberrant specializations of the better known tarsioids, the dental formula is properly reduced from the primitive 2.1.4.3. to the advanced 2.1.2.3., and the molars are relatively primitive, much more so than those of the contemporary *Propliopithecus hœckeli* Schlosser. The lower jaw and dentition of this interesting genus appear to form a perfect archetype for the whole anthropoid-man group, as first noted by Schlosser. The evidence from the jaw of *Parapithecus* then does not forbid us to derive the anthropoid-man series from some primitive tarsioid, although by itself this evidence is quite insufficient to prove this hypothesis, for the status of *Parapithecus* itself as a tarsioid is hardly beyond question.

Particularly open to criticism are Wood-Jones's views that the African anthropoids are the offshoots of the *Cercopithecus*-baboon group and that the gibbon and orang are related to the langurs. The dentition alone is sufficient to prove that, whatever the relationships of the anthropoids to man may be, the orang is more nearly related to the chimpanzee than it is to the langur and that the *Cercopithecus*-baboon group is widely separated from the chimpanzee and the gorilla.

Wood-Jones refers briefly to the palæontological history of the different divisions of the Primates but a good part of that palæontological history is known chiefly from the evidence afforded by the jaws and teeth, as to the first appearance, phyletic succession by horizons and geographic distribution of the different families. Long continued comparative study of the dentition of recent and fossil mammals testifies emphatically against Wood-Jones's views that man has been derived from a *Tarsius*-like type, that the African anthro-

poids are the terminal members of a quite different primary division of the haplorhine primates, and that the hundreds of their anatomical resemblances to man are to be set down as convergences and to be outweighed by the variable contacts of the bones around the pterion and in the anterior cranial fossa.

THE NAMES OF THE FALLING SICKNESS AN INTRODUCTION TO THE STUDY OF THE FOLKLORE AND CULTURAL HISTORY OF EPILEPSY

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Medical folklore is usually considered more or less of a hobby. It is true enough that the busy general practitioner cannot find the time or the opportunity to bury himself in the vast and oftentimes not at all easily accessible literature, which contains the numerous and widely scattered bits of information about the customs and manners of the various nations dealing with the nature and treatment of human ailments. The specialist, seriously engaged in useful modern research, can ill afford to interrupt his work with the study of beliefs, which he naturally abhors as pure superstitions. It is frequently enough the present-day physician's task to put up a struggle against prevailing misbeliefs; being called upon to eradicate them and to educate the public, he is certainly not to be blamed if, in his justified contempt of the persistence of medieval thinking in the era of Edison and Einstein, he does not feel the urge of making himself thoroughly acquainted with the development and remainders of a passing civilization. To the medical historian, finally, folklore is an interesting side issue; he does not exactly exclude it from the scope of his topics but looks upon it rather as a Cinderella, which to him does not seem to deserve the serious attention of a scientist.

If we regard medical folklore as the sum total of those traditional concepts and practices occupying themselves with the normal and abnormal functions of the human organism, which cannot be explained by, or are directly opposed to, the scientific convictions of our day, then we must honestly admit that the very bottom of the pyramid, the top of which we aspire to reach, is made up entirely of folklore. The narrower the pyramid becomes in its upward striving, the more readily the original errors are recognized as such, and the future will show how much of it still exists that has been taken over by our

incomparably more enlightened generation. In view of the intimate connections existing between popular and learned medical lore until surely not more than about one hundred and fifty years ago, it would be difficult, if not impossible, to attempt an artificial separation of folklore from cultural history.

This is particularly true of epilepsy, which, because of the suddenness and uniquely dramatic effect on the onlookers of the single convulsion, has for thousands of years practically everywhere been more easily recognized and received more attention than any other individual ailment. Many diseases, which in olden times demanded a heavy toll from mankind, have become so rare in large sections of our globe, that the folk has almost forgotten them; there is nowadays very little folklore of plague or leprosy to be found in the western European countries. Other conditions, unknown to, or not recognized by, our forefathers, have assumed greater importance in the course of time. But epilepsy, chiefly that which manifests itself in the form of the typical grand mal attack, has from time immemorial until to-day kept puzzling the untutored minds of the primitive peoples as well as of that superstitious portion of civilized humanity which has found it too difficult to keep pace with the rapid progress of logical and scientific thinking. It is, therefore, easy to understand why the falling sickness has come to command over as large a host of traditions as has the universally known sensation of toothache or the equally universal process of childbirth.

ETYMOLOGY IN CULTURAL HISTORY

There is hardly anything more interesting and fascinating from the point of view of cultural history than the material furnished by the science of etymology. It not only leads us back to a much earlier period of human civilization than do most other methods of historical research, but it also teaches us that names, which to-day are merely appellations or allusions to something, are of much greater importance to the primitive mind. To Shakespeare and to us, a rose would have its characteristic scent, no matter what it be called. But our early ancestors as well as later mystic systems saw in the name of a subject one of its very concrete properties, just as telling as its color or shape. The pallid derivations from meaningful expressions, which form our modern vocabulary, have, at least to the philologically untrained mind, lost their intimate connections with the things for which they stand and have obtained a meaning rather through their sound and

spelling then through a realized relation to the objects in question. Even the most recent word formations, derived from the ancient languages, have this fate; a telephone is a "far speaker" only to one who knows the origin of the word; to the others it is merely a memorized sequence of sounds or letters intended to allude to a certain convenience. The reason why the fish has been selected as a symbol of early Christianity can be understood only by those who are aware of the fact that the Greek word for "fish," ΙΧΘΥΣ, came to be looked upon as a contraction of the initials of Christ's name and nature: Ἰησοῦς Χριστὸς Θεοῦ Υἱὸς Σωτήρ (Jesus Christ, God's Son, Savior).

EPILEPSY AS A POSSESSION BY SPIRITS

It is due to this fading of the original meaning of a word in the course of centuries that to-day the scientific name of the falling sickness is so utterly unscientific, if viewed etymologically, and goes back to the old belief in the demonic origin of diseases. The term epilepsy, Greek ἐπιληψία, is derived from the verb ἐπιλαμβάνομαι, to be siezed, tc be overcome. The one who overcomes or seizes the patient is a god or a demon. The words attack and seizure, which are now used commonly in the most purely scientific medical writings, had after all a very similar development, except for the fact that they were used much more generally, never being reserved for a definite condition. Since practically all other popular names of the falling sickness are composed of two words, it is perhaps due to no other reason than its relative shortness that the term epilepsy has at a rather early period come to occupy a privileged position among the numerous designations of the ailment. For a long time it had to compete more or less pronouncedly with a number of other terms, until it gained its final, undisputed and unopposed supremacy as the scientific name par excellence. Its etymology has always been well-known to the medical world since the day of Hippocrates. It is therefore rather surprising to find that Thomas Burnet,[13] in 1685, devoted a special chapter of his *Hippocrates Contractus*, published in Edinburgh, to prove that the word is not derived from the alleged hybrid combination of Greek ἐπι and Latin *laedo*, thus meaning a sudden insult (*laedo* is the verb from which "lesion" is derived).

Since the term epilepsy indicates a passive condition in which the patient is suddenly overcome by a supernatural force, it is extremely interesting to see just what kind of beings, be they divine or

devilish, were held responsible by the various nations of the past and present.

Hippocrates, who was an admirable critic of contemporaneous superstition, tells with a certain degree of sarcasm of the different gods who were said by certain magicians of his time to bring about the different forms of epileptic seizure. They maintained that if the patient imitated a goat, or ground his teeth, or if the right side was convulsed, Hera, the mother of the gods, was the cause. If he spoke in a sharper and more intense tone his state was likened to that of a horse, and they believed Poseidon should be invoked. If any excrement was passed, the appellation of Enodius was adhibited. If it was passed in smaller or denser masses, like a bird's, it was said to be sent from Apollo Nomius. If foam was emitted from the mouth and the patient kicked with his feet, Ares got the blame. Night terrors, delirium, jumping out of bed, frightful apparitions, running away, were the plots of Hecate, that mysterious goddess of sorcery, and the Heroes.[25]

In Rome it was the evil spirits who were accused of causing the malady.[30c] One of the almost innumerable Latin names of epilepsy directly referred to its alleged origin; it was called *morbus daemoniacus*, or *morbus daemonius*. Since the patient, possessed by a demon, had the power of the evil eye and thus was thought capable of transmitting his ailment to others, one naturally had to be on one's guard and to avert the impending calamity by methods which were then believed to protect against the workings of the evil eye. Spitting was, and in many regions still is, the most efficient measure. Therefore, upon the sight of an epileptic, one warded off the danger of becoming subject to convulsions by spitting at the patient. Owing to this habit, which was apparently in common usage, the malady was given the name of *morbus insputatus*, the disease that is spit at. According to Seligmann[45], the ancient Romans also used to spit at themselves in order to be protected against epilepsy. In Plautus' comedy, *The Captives*, someone who is believed to suffer from the falling sickness raises this question: "Is it that I suffer from the disease which one uses to spit at?"[40] In view of all this, it is quite incorrect if Spratling, in his classical book on epilepsy and its treatment, defines *morbus insputatus* (he has "*insputatis*") as the spitting disease and adds that "this may be more graphically than elegantly translated as the 'slobbering sickness'."[47a] As late as 1687, Wolfgang Wedel wrote a treatise on epilepsy (published in Jena), which has the title: *De morbo insputato*, and explains

the term by saying that "veteres in epilepticos exspuerunt" (the ancient people spat at epileptics).[53]

The Hindus had a special demon whose chief function it was to cause convulsions. Her name is in its meaning very similar to that of epilepsy. She was called Grāhī, which means: "she who seizes." Atharvaveda makes mention of her on three different occasions.[30b] In modern India, however, a dog-demon is accused of seizing the patient, and it is of interest that the dog-demon therefore plays an important part in the Hindu folk-treatment of epilepsy. When a person falls down in a convulsion, the father or another competent person wraps the patient in a net and carries him into the hall, not through the door but through an opening in the middle of the roof. Then, taking up some earth in the middle of the hall at the place where the people gamble, he lays the patient on his back on the dice. After that he prays to the dog-demon saying: "Doggy, let him loose! Reverence be to thee, barker, bender!"[54] The place where people gambled, says Frazer in his *Golden Bough*, was for some reason supposed to be a spot where an epileptic could divest himself readily of his malady.[18]

The Babylonians and Assyrians also had a special demon of epilepsy who was called Labasu.[30a] The Arabs attributed the fit to the blow of a ghost on the hollow of Jacob's thigh.[2] The Turk who falls down in a seizure is in conversation with supernatural beings. He has secret relations with a negress; a spirit who is in love with the same girl surprises his rival, seizes him by the throat and attempts to choke him; hence the loss of consciousness and the cramps. If it is a woman, she is believed to have an illicit affair with a negro; a demon who loves her and catches her in flagranti, tries to throttle her in revenge.[29]

In Ethiopia, epilepsy is traced either to possession by a demon or to the shadow of an enemy, which has fallen on the sufferer. The Persians, when they experience a convulsion, are inhabited by one or several jinns, mythological beings supposed to have been created two thousand years before Adam. The Moroccan name for epileptics expresses that superstition very distinctly: *medjnun* denotes one who is infested by a jinn.[29g]

Among the natives of the Luang-Sematta Archipelago, the attacks are brought about by the presence in the patient's head of a goat's spirit, whereas the aborigines of the island of Welar are positive that not a goat is to be blamed but a certain bird by the name of Perlika, whom the evil gods manage to deposit in the interior of the patient's

skull.[29e] The Albanians have no name for the disease; they would much rather mention the devil, which would be ominous enough, than epilepsy, which is caused by the activities of a female demon, Flamea. Speaking of a man in a convulsion they say: "He lies in the known settlements with the demon", or simply: "The thing has overcome him."[29g]

These are only a few examples, selected at random, illustrating the belief in demoniacal possession, to which the falling sickness owes its now scientific name. The modern spelling and pronounciation is relatively young. In the Middle Ages, and also later, a great many different forms were used, often several spellings by the same writer. Thus we find the terms *epilence, epylencia* (Trevisa, 1398), *epylencye, epylence, epilencia, epilepse.*[12,37] J. Whitehouse, in 1804, in a poem addressed to "*Febris*," speaks of

> That hideous choir,
> Marasmus, Epilepse, and Frenzy dire.

We find a very similar development in the other modern languages, particularly those of the Romanic group. It is perhaps due to the two different Greek forms, ἐπιλῃψία and ἐπιλημψία, the latter being the Ionic variety used in the writings of Hippocrates, who meant by the word rather a convulsion than the malady on the basis of which the fit arose. It is natural that there exists at least as large a variety of adjectives as of nouns. Thus we find words, such as *epulentyk, epilentycke, epylentyk, epilentic,* the *epylentical* passyon, etc.[37]

A term, which is very popular and the equivalents of which may be found in practically every language, is the descriptive name of falling sickness. It is strange that the ancient Greeks had no corresponding word. The Romans spoke of *morbus caducus* (French: *mal caduc*), the common German name is *Fallsucht,* or *fallende Sucht,* the Slavic equivalent is *padanica,* from the Slav root *pad-,* to fall. Dropping down in a convulsion is also the meaning of the Old-Scandinavian names of epilepsy: Old-Norwegian: *brotfall;* Old-Swedish: *brutfall;* Old-Danish: *brottfælling* (*brôt* = convulsion).[23] In modern Norwegian the term *nefallssott* is employed. In any event, the designation "falling sickness" is certainly more scientific, more to the point, and alludes better to the nature of the condition, or at least to its most outstanding symptom, than the word epilepsy.

A considerable number of the other names of epilepsy may easily be dealt with under two prominent aspects. In one group of

words we find an extreme awe, an admiration and actual deification of the epileptic and of his condition, in the other we recognize an expression of utmost horror, contempt, and disgust.

EPILEPSY AS THE SACRED DISEASE

Beginning with the first group, we may state that epilepsy finds its most complete apotheosis in the writings of the Hebrew Cabala. This mystic system works a great deal with the principle of putting together the first letters of several words, thus forming a new word, which has some mysterious connection with the original sentence or group of words. In this manner the initials of the Hebrew name for epilepsy, *choli nophel* (falling sickness), are contracted to form the word "*chēn.*"[52] *Chēn* means "harmonious beauty" and is, in the Cabala, one of God's highest attributes. Thus the epileptic, during his convulsions, is made to share one of the most outstanding properties of the Deity. Epilepsy, as a matter of fact, has always been looked upon as a divine and god-making condition. The Prussian peasants still call it "*das Höchste,*" the Highest, and the attitude of the Russian people is best expressed by the words of their greatest epileptic, the famous novelist Fiodor Dostoyevsky. "There are moments," he says, "and it is only five or six seconds, when you suddenly feel the pressure of eternal harmony. This phenomenon is neither terrestrial nor celestial, but is an indescribable something which man in his mortal body can scarcely endure." And in another place he says: "What matter, after all, though it be a disease, an abnormal tension, if the result includes the highest degree of harmony and beauty?" Is it surprising, then, if the most common name of the condition in ancient Greece and Rome was that of the sacred disease (*ἱερὴ νόσος, morbus sacer*), or of the divine malady (*τὸ θεῖον, morbus divinus*)? Herodotus, in the third book ("Thalia") of his monumental work, speaking of the incongruous behavior of the Persian King Cambyses, tells that he was suffering from the sacred disease. Hippocrates called his monograph, the oldest on the subject, *περὶ ἱερῆς νόσου*. It is a cultural document of the first order, giving testimony to the great insight and common sense of its author. To those who thought that epilepsy was divine, he replied: "Indeed in my opinion these maladies like all other things are divine, and no one thing is more divine or more human than another, for all things are alike divine; yet each one of them has its own natural properties and cannot come into existence without natural causes."[25] Aretaeus of Cappadocia tried

to find a plausible reason why epilepsy was named sacred. He mentions several possibilities: it is called *ἱερή*, because this word not only means holy, but also great, as may be proved by various combinations, particularly in connection with the sea, the night, the house, and with certain cities; because the disease cannot be influenced by human aid and medical assistance, but only with divine help; because a demon has taken possession of the patient, who cannot be relieved of his disease by means other than the arts of magic.[6] Caelius Aurelianus adds to this list one other possible reason: because the convulsion "soiled the sacred soul" and because its seat was in the head, "which in the opinion of many philosophers is the holy temple of the soul."[7] The common people, of course, knew nothing of such rationalizations by the learned writers. To them, epilepsy not only was actually a sacred condition, but elevated the patient, at least during the convulsion, literally to the rank of a god. The Latin name, *morbus deificus*, is an unmistakable reference to this superstition. It is certainly not a mere coincidence that epileptic or epileptiform seizures have been ascribed to so great a number of prophets and priests and to practically all the greatest personalities that have ever lived. A great deal of argument has been spent on the question whether or not Alexander the Great, Julius Caesar, Napoleon Bonaparte, Peter the Great, Charles V, Mohammed, Saint Paul, Richelieu, Swedenborg, Molière, Swift, Petrarch, and others, suffered from epilepsy. In most cases we have not enough facts to come to a definite conclusion. But the thing that seems particularly interesting is that, even provided some of the persons mentioned were not subject to the falling sickness, tradition has maintained the firm belief in the occurrence of epilepsy among the most adventurous conquerors, the most energetic religious reformers, the greatest mystic of his time, and some writers, artists, and scientists who have attained world fame (van Gogh, Flaubert, Dostoyevsky, Buffon, Helmholtz). It would be a fascinating study, deserving the efforts of a Maurois or Ludwig, to get these things as straight as a historical retrospection would permit, and to try to establish the connections between the epileptic attack with its aura on one hand and the world conquerors and reformers with their attempts to reach out into the cosmic vastness on the other hand. Spratling, who may be credited with an intimate knowledge of epilepsy, says of the epileptic aura, summing up the experiences of some of his patients, that it is "the most overwhelming ecstatic state it is possible for the human mind to conceive."[47c]

We know that the pythonesses, those soothsaying priestesses of Apollo in Delphi, were recruited largely from women who experienced fugues and convulsions. Balaam, the Midianite seer, speaks of himself with great pride as "*nophel*," an epileptic.[8a,42] As late as the thirteenth century, we find in a book entitled *Ancren Ruele* and edited by Morton in 1853, the following very interesting passage:

> Another property, which is very good for an anchoress, although it is hated; that is the falling sickness. For it is very necessary for an anchoress of holy and highly pious life to have the falling sickness. I do not mean the sickness which is commonly so called, but that which I call falling sickness is an infirmity of the body, or temptation of carnal frailty, by which she seems to herself to fall down from her holy and exalted piety. She would otherwise grow presumptuous.[4]

We will for an instant discard all our present knowledge of epilepsy and try to look upon it with the eyes of a superstitious, illiterate, ancient or medieval observer who is just witnessing a typical epileptic grand mal seizure. He may or may not in the preceding few minutes have noticed some slight alteration in the patient's expression or behavior. But all of a sudden right in the midst of the conversation he hears a strange, inexplicable outcry, unwarranted by the situation. Before he can look around and try to account for the outcry he sees the patient drop down like a log with foam bubbling between his lips, his consciousness gone, his limbs jerking in an uncontrollable convulsion. Soon the attack subsides and the patient relaxes. Tomorrow the sufferer will again be capable of carrying on a normal conversation, not remembering anything of the dramatic episode that has taken place the day before. But some of the observers may have noticed that the person who is subject to fits may be of a highly religious nature, that he may assert that he has had communications with supernatural forces. What is more natural than to combine the incidence of the fits with divine holiness? What is more logical than to arrive at the conclusion that the falling sickness is a necessary requirement of a pythoness or an anchoress? What is more cogent than the inference that during the seizure the patient's soul is carried away into the supernatural realm of divine existence? And in the presence of some imagination, what is more probable than the belief that epilepsy is indeed a *morbus deificus*, a god-making, holy, great disease, a *morbus major* (Celsus)[14], or μεγάλη νόσος, *haut mal* of the French, *velika bolest* of the Croats?

To the Greeks, Hercules, or Heracles, was the greatest and strongest man that ever existed; he was raised by the gods to the rank of a hero.

According to Aristotle, Hercules suffered from the sacred disease, which accordingly has been named *morbus Herculeus* or *Heracleus.*[31] Again we meet with various attempts at rationalization. Thus, Galen and Alexander of Tralles thought that the hero's final condition was not due to epilepsy, but that the ailment was named after him because of its strength and violence (*propter robur et vehementiam*), which could be compared with naught but the hero's unexcelled physical powers.[1] Other derived the name from the fact that epilepsy is just as invincible as the demi-god of the fable; and still others, precursors of the modern investigators of human constitution types and their relation to certain pathologic states, compared the somatic habitus of the majority of epileptics with the statues of Hercules, presenting him as a bulky, corpulent individual, and came to the conclusion that the disease owed its name to the clumsiness and obesity of its victims.[31]

EPILEPSY AS THE DREADED DISEASE

Diametrically opposed to the group of designations in which the epileptic is deified and reverenced, is another series of terms expressing the emotions of horror, contempt, and detestation, with which the seizure is viewed by those observers who have not enough imagination to see in it the characteristics of sanctity or apotheosis. The two principal effects, which, according to Aristotle, are indispensable postulates of a tragedy, pity and fear, play also a very important part in the evaluation of an epileptic fit. The patient's passivity and helplessness, his incurableness, the traumatic results of the fall and, above all, the frequent incontinence of urine and feces, are apt to evoke a feeling of compassion. On the other hand, just as in a tragedy, one may come to fear that the same tantalizing situation might occur to oneself, particularly if one considers the old belief in the contagiousness of the falling sickness, either by transmission through the "evil eye" or by communication through the saliva or other channels of infection. In the Middle Ages epilepsy was indeed regarded as a contagion.[20a] A pseudo-Salernitan verse, cited by Bernard de Gordon in 1307, the idea of which derives from the Arabian physician Rhazes, names the following eight diseases which were then believed to be communicable: bubonic plague, phthisis, epilepsy, scabies, erysipelas (*ignis sacer*), anthrax, trachoma, and leprosy. According to Garrison, the notion of epilepsy as a contagion sprang, as Sudhoff thinks, from the ancient Assyro-Babylonian concept of seizure by demons (*sibtu*), the ἐπαφή (*contagium*) of the Greek papyri

of 77–350 A.D. as applied to the sacred disease of the Hippocratic canon. In a pest-tract of the fourteenth century, written by Henricus of Prague, the eight transmissible maladies are reduced to five, in which the falling sickness figures as the fourth; they are fevers, pests, leprosy, epilepsy, and catarrhs.[20b] It is therefore not at all surprising to learn that in 1486 an isolation hospital and home for epileptics was founded at the cloister of St. Valentine at Rufach in Upper Alsace.[20c] In Swabia the saliva of epileptics is still considered poisonous.[29]

A review of the names of epilepsy pertaining to the second group shows that the dread of the disease is not less common than its deification. It finds its expression in designations such as "the grievous disease" of Old-England (Thomas Phaer, Boke of Children, 1544, has "*the gryevouse syckenes,*")[39,44] "*die schwere Not,*" "*die böse Krankheit,*" "*das böse Wesen*" of the Germans, the "cadaverous disease" of the Slovaks, the "bad sickness" (*schlechte Krenk*) of the Yiddish speaking Jews,[52] "*il brutto male*" of the Italians, the "black disease" (*cornaja slabist*) of the Ukrainians, the "horrible sickness" (*strašna bolest*) of the Serbs and Croats. Grimm, in his *German Mythology*, gives this list of terms for epilepsy: *Jammer* (misery), *Elend* (wretchedness), *böses Wesen* (bad being), *Staupe* (scourge), *Unkraut* (weed).[21] *Nužda*, or misery, is one of the names which the Ruthenians give to the disease. Epilepsy is also the most dreadful condition which the German inhabitants of Northern Bohemia know; they speak of it only as "*das Ungelücke,*" the misfortune, par excellence.[22] *Morbus foedus*, the filthy disease, is one of the many Latin epithets. Lucius Apuleius, the well-known Roman satirical writer and physician, author of the *Golden Ass*, who was perhaps the first to describe the occurrence of epileptic seizures in animals (a donkey), speaks of the malady as *morbus detestabilis* ("*asellus morbo detestabili caducus*").[5b]

In Roman law, epilepsy was one of the serious disorders which excused the sufferer from duty. It was a "*morbus sonticus.*"[41] The original meaning of this adjective is dangerous, noxious, critical; in legal language it included all those conditions which made it impossible for the individual afflicted with them to perform his duties successfully and to assume any responsibilities. It is in this connection very interesting to learn that epilepsy played a very important part in the public life of Rome and of the Byzantine Empire. When, during the comitia, a popular assembly called to attend to elections or legislation, one of the participants fell down in a convulsion, the consultation

was immediately suspended. Such a day was a "*dies nefastus*," a nefarious day, or "*dies religiosus*."[31] From the legal prescription necessitating the interruption of the comitia upon the occurrence of an epileptic fit, the disease received the name of *morbus comitialis*, which was introduced into medical literature by Celsus.[14] I doubt the correctness of the statement of those later authors according to whom the term owes its origin to the alleged fact that epileptics were prone to manifest their illness during the comitial gatherings. Another legal aspect of epilepsy is contained in a number of sales contracts published by Sudhoff.[48] The purchase of slaves in the first post-Christian centuries was almost always accompanied by the clause that the vendor would return the sum paid for the slave if in a period of six months following the sale it appeared that the slave suffered from the sacred disease. It was believed that the fumes ascending from burning jet (*gagates*) had something of the result which now are claimed for hyperventilation, namely, to provoke a convulsion in predisposed persons and thus to disclose a tendency to epilepsy.[17,41]

In view of the horror and dread which the epileptic seizures evoke in the onlooker, it is easy to understand why the face of an epileptic is covered with a cloth during the fit. To this custom the disease owes another of its designations, that of "*larvatio*," the covering, or veiling, or disguise, which is not used anywhere at present, but which may be found registered in a number of glossaries.[26] The cloth should be dark, either blue or black, and it is particularly helpful if it is consecrated by the touch of the relics of a saint. The Ruthenians cover the patient with a trough, upon which they break a pot, both as a curative measure and as a means of protecting themselves against contagion.

In the opinion of some people it is not only dangerous to see the sufferer's face during the fit, but one should not even when speaking of the disease call it by its name. Thus the Franks allude to it merely as "'*s Wesen*" (the thing), and the Ukrainians often mention it as "*ta slabist*" (that sickness).[29] It is interesting to compare this with a statement made by George Huntington in his memorable address at Middleport, Ohio, on February 15, 1872, in which he presented for the first time a description of cases of hereditary chorea later named after him; he said that the afflicted Long Island families, particularly the younger members who, not yet being affected, felt the impending danger like a sword of Damocles, dreaded to call the chorea by its right name and spoke of it merely as "that disorder." This is also

the reason why so many people, even if they do pronounce the name of epilepsy, never raise their voices above a whisper. The Portuguese also often speak of the disease only as *enfermidade* or "the sickness."

So unparalleled indeed did epilepsy appear to be in the eyes of some medieval authors that they coined for it the name of *morbus unicatus*, the unique disease. The adjective seems to have been created for this special purpose, since it is not contained in any of the earlier Latin writers and one looks for it in vain in the standard Latin dictionaries.

PATRON SAINTS OF EPILEPSY

Epilepsy, like practically all diseases known to the people, has its patron saints, who contribute very generously to its nomenclature. St. John and St. Valentine enjoy the greatest popularity. In Flanders the belief exists that God punished St. John with epilepsy because he asked Him pertly to show him the thunder.[29b] Ambroise Paré tried to explain the name of "*mal de St. Jean*" by saying that, as the epileptic falls down in his convulsion, so the head of the saint fell to the ground when he was decapitated;[15, 31] and Delasiauve, in his treatise on epilepsy, makes this statement: "L' époque de St. Jean, en raisons des grandes chaleurs, était fertile en épilepsies."[16] Among the numerous antiepileptic charms and remedies, there are quite a few which directly or indirectly have reference to this patron of the falling sickness: leaping over the fire of St. John;[3] wheat flour mixed with dew gathered on the morning of St. John's Day and made into a cake;[34] St.-John's-wort taken internally or in the form of amulets.[29b]

The designation of St. Valentine's disease for epilepsy is, according to Höfler, due to the resemblance in sound of this saint (in German *v* sounds like *f*) to the term *fallende Sucht*. Such a selection of patron saints because of a vocal similarity of their names to that of the disease in question is not at all unique in folklore. Thus St. Quentin came to be the intercessor for those suffering from the quintan fever, St. Eutrope became the patron of hydropic conditions, and St. Genou of pains in the knees ("*maux de genou*").[27] A medieval herbal speaks of St. Valentine as the "ordinary in epilepsy." Kissing or touching his relics on his day, February 14th, in the Franciscan Church at Würzburg, Bavaria, is considered an infallible cure of the falling sickness.[29a]

In the region of the Abruzzi, in Italy, particularly in the region of Teramo, the intercession of St. Donato is the most helpful measure.

His virtues are so great if invoked for help that the condition is called the malady of St. Donato.[33] To some inhabitants of western and southern Germany, of Belgium and the Netherlands, it is also known as the disease of St. Cornelius. When one of the patient's relatives by means of begging can collect a quantity of corn, which weighs as much as the sufferer himself, and offers this to St. Cornelius, the saint will put an end to his misfortunes (Van Andel).[3] In many churches he is the principal patron of epilepsy.[10] St. Christopher was also invoked against this disorder; his statues and pictures often bore the inscription: "Whoever shall behold the image of St. Christopher, shall not faint or fall on this day."[35] Other saints who in various localities take the place of those already mentioned are St. Anna,[29f] St. Helena,[24] St. Fabian, St. Sebastian, St. Hubert,[29d] St. Ulrich,[29c] and St. Anthony, whose chief function is the cure of another sacred illness, *ignis sacer*, or erysipelas. According to Pavitt, "St. Anthony was habitually invoked for the cure of epilepsy as well as erysipelas. The Tau Cross was the sign adopted by Anthony the Copt, an Egyptian hermit gifted with the cure of erysipelas (St. Anthony's fire) and this cross came into great favor, particularly among the Jews, who used it in conjunction with various magical formulae both for erysipelas and epilepsy."[38] None of the saints, however, has contributed so much to the therapy of the falling sickness as have the Three Kings, though they have, strangely enough, failed to add to its many names. In England it helps if one writes, with blood taken from the sick man's finger, these lines on an amulet, which must be worn around the neck.

> Caspar fert myrrham, Melchior thus, Balthasar aurum;
> Haec tria qui secum portaverit nomina regum,
> Solvitur a morbo domini pietate caduco.

(Caspar carries myrrh, Melchior incense, Balthasar gold; whoever wears with him these three names of the Kings, is freed from the falling sickness by the piety of the Lord.) Van Andel thinks that the Three Kings are patrons of epilepsy, "probably because they fell down before the child Jesus and worshipped it."[3] Peter of Abano (1250–1316) advised to quiet paroxysms of epilepsy by pronouncing the names of the Three Magi in the patient's ear.[50] It is strange to notice that the quoted Latin formula has become so popular that it may be found everywhere in Europe, in the Romanic, Germanic, and Slav countries.[49]

"*Haint Tegla*" or "*clwyf Tegla*" or St. Tecla's disease, is one of the many Welsh names of epilepsy. The Welsh have almost as many

designations for the condition as had the ancient Romans. They call it "the great illness (*y gloesion mawr*), the blessed sickness (*y clefyd bendigaid*), the fainting disease (*masglwyf* or *llesmeirglwyf*), the falling sickness (*clwyf dygwydd* or *gloesion bwrw*)." A name that does not seem to have an equivalent in any other language is that of *gwialen Crist*, or Christ's rod; I have not been able to find a satisfactory explanation for the formation of this designation for epilepsy.[19]

The virgin martyr St. Tecla is, in Wales, the patron saint of the falling sickness. In the village of Llandegla there is a church dedicated to her, where the disease used to be, and probably still is, transferred to a fowl. Black (Folk-Medicine, London, 1883),[9a] Brand (Popular Antiquities of Great Britain, London, 1882–1883),[11] Frazer (The Scapegoat, London, 1913)[18a] and several other authors have given interesting descriptions of this procedure. The patient first washed his limbs in a sacred well hard by, dropped four-pence into it as an offering, walked three times round the well and repeated three times the Lord's Prayer. Then a cock (if the patient was a man) or a hen (if the sufferer happened to be a woman) was put into a basket and carried round first the well and afterwards the church. Next the patient entered the Church and lay down under the communion table till break of day. After that he offered six-pence and went away, leaving the fowl in the church. If the bird died the sickness was supposed to be transferred to it from the man or woman, who was now rid of the disorder.

EPILEPSY AND THE MOON

A further group of names refers to the assumed connection between epileptic seizures and stellar influences. Nowhere has folklore taken so strong a hold of the medical profession as in the question of cosmic relations to disease, particularly to the falling sickness, somnambulism, and goiter.[28] Sieveking wrote as late as 1861: "Lunar influences are still upheld by some physicians of repute, and the belief is generally in vogue among the public. Epileptics were termed moony or moon-struck."[46] The superstition that the condition is always worse during the moon's phases, was, at least for the profession, destroyed by Moreau, whose paper on the etiology of epilepsy (1854) was therefore a cultural deed and fully deserved the prize which was awarded it by the Paris Academy of Medicine. He showed that of the 42,637 attacks observed by him, 26,313 were between the phases of the moon and only 16,324 occurred during its phases.[36]

According to St. Hildegard of Bingen (1098–1179), one sometimes incurred epilepsy when the moon was in eclipse.[50] And Richard Mead, who wrote a learned treatise on the influence of sun and moon on human bodies, stated that the moon governs the period of epileptic cases, and that when he had met sailors who had contracted epilepsy by frights in sea-engagements or storms in Queen Anne's wars, he was often able to predict the times of the fits "with tolerable certainty."[55] This belief in the dependence of the fits upon the phases of the moon is very old. It gave origin to such names as *morbus lunaticus* (also employed for various forms of mental disorder), *astralis*, *sideratus*, *interlunis*, and *seleniacus*. The latter name reminds one of the Greek term σεληνιαζόμενοι, which, in the New Testament, evidently refers to epileptics. Thus, in Matthew XVII: 14–15, we read: "And when they were come to the multitude, there came to him a certain man, kneeling down to him, and saying: Lord, have mercy on my son, for he is lunatick, and sore vexed: for oftentimes he falleth into the fire, and oft into the water."[85] Aretaeus of Cappadocia tells us that in his time (first century) the people believed that those subject to fits had sinned against Phoebe, the goddess of the moon, and that lunatic was therefore a synonym for epileptic.[6] Monkey's heart was a valued remedy in the case of falling sickness, because this animal was sacred to the moon-goddess Selene, and among the Egyptians to Thoth, who, originally a moon-god, later became also the patron of wisdom, learning, and magic, and the inventor of numbers and letters.[28] The ancients also often thought that the patient had received a blow from a star, or was blasted by the influence of some heavenly body. Spratling believes that the frequency of the visual aura, when the patient sees flashes of light, stars, or other luminous bodies, may have helped to bestow the name of *morbus astralis*.[47b]

It may be mentioned that the Scandinavians of old translated the word *lunaticus* literally by "*tungloer*" (from *tungl* = moon, and *oerr* = mad),[23] whereas the corresponding German term *mondsüchtig* hardly ever refers to the falling sickness.

The names *morbus scelestus*, the criminal disease, and *perditio* allude to the brutally aggressive and destructive tendencies of some epileptics; *morbus viridellus* (greenish) and *morbus vitriolatus* depict the change which an epileptic attack effects in the patient's complexion, the face in its paleness suggesting the color of "green vitriol" (ferrous sulphate). *Morbus mensalis* (disease of the table) and *morbus convivialis* (disease of banquets) reminded of the frequency with which

convulsions were apt to come on while the patient participated in opulent meals. The word *apasmara*, which one finds in Sanscrit texts at the designation of epilepsy, means "forgetfulness" and alludes both to the loss of consciousness during the attack and the amnesia following it.[32] The Siamese speak of epilepsy as *"lom bah muh"*; *lom* means typhoon, also disease, *bah* signifies mad, and *muh* means pig. Epilepsy impresses the Siamese as a whirlwind or a whirling, violent muscular activity resembling that of an angered hog,[51] not "dog," as Rasch[43] has it. I do not exactly know why the Arab physicians (Avicenna) called epilepsy *mater puerorum*, the mother of the boys, of which name Delasiauve speaks as "une dénomination étrange et inexplicable,"[16] nor was I able to ascertain the precise origin and meaning of the Spanish term *mal de corazon*[15] (*"corazon"* may mean heart, or courage, or benevolence). The French have a name which is derived from the fact that the patient falls to the ground: *mal de terre.*[15,16,31]

With the list given in the above paper, the number of names of the falling sickness is not exhausted by far. But I hope that the selection offered demonstrates clearly the tremendous importance attached to epilepsy and the grand mal attack by the various peoples of the earth and the different evaluation of the convulsions and the people subject to them, often by members of the same nation.

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THE "LAWS" OF SEROLOGIC RACE-CLASSIFICATION STUDIES IN HUMAN INHERITANCE IV

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For some years I have been advocating the application of blood group distribution to anthropologic problems. Thus far the suggested applications have been general, perhaps even vague. It is the purpose of the present paper to present in tentative form some definite laws of serologic race-classification, in the hope of crystallizing opinion on this subject.

The blood group problem, originating with Landsteiner's discovery of the groups as a laboratory phenomenon, has rapidly widened its scope of usefulness until today there are four main lines along which practical applications of blood grouping may be laid down. These are, first, blood transfusion; second, legal medicine, including the determination of disputed parentage, the identification of blood stains, and the identification of the newly born in hospitals; third, pathology, including the genetic and ontogenetic relationships of blood groups to various pathological, morphologic, and physiologic conditions; and fourth, anthropology.

For each of the first three of these fields we have been able to construct definite serologic "laws" embracing the specific practical applications involved in that field. I have outlined and elaborated such laws in previous papers (Snyder, 1926, 1927). For the last field, that of anthropology, however, I have hitherto limited myself to generalized statements. It seems to me that we have now reached the stage where serologic "laws" relating to race-classification may be offered comparable to those available in the other fields.

My studies of the heredity and development of the blood groups have convinced me that the groups may take their place as additional criteria for use in racial classification. I realize, and in fact emphasize, the limitations of the blood groups in this field, but I recognize also their possibilities. As to the limitations of the blood groups as anthropologic criteria, I have repeatedly emphasized the fact that

the groups do not possess any mysterious potency as racial criteria because they are hidden in the blood. If they are accepted as of anthropologic value, they must merely take their place along with pigmentation, hair form, cephalic index, and the rest. In certain things, however, the blood groups do possess an advantage over certain other criteria. These will be discussed in their turn.

There are six points upon which the anthropologic value of the blood groups rests. These are first, the demonstration of the heredity of the groups; second, the stability of the groups under varying environmental conditions; third, the impossibility of conscious selection in the case of the groups; fourth, the striking variation in blood group distribution among various races; fifth, the constancy of the groups from generation to generation in the absence of crossing; and sixth, the definite change in blood group proportions due to racial crossing. These will be considered one at a time.

The heredity of the groups has been definitely established as based on three multiple allelomorphs (Bernstein, 1925; Snyder, 1926, 1927, 1929; *et al.*). More than four thousand family histories are now available, and practically all recent writers on the subject have accepted the triple allelomorph hypothesis. Depending on three multiple allelomorphs, the blood groups have an advantage as criteria for anthropologic use in that the double dominant (group AB) is phenotypically recognizable, making a study of the frequency distribution of the allelomorphs readily available.

The second point, that of the stability of the groups under varying environmental conditions, has been amply demonstrated. The data on this point have been summarized and discussed in previous papers (cf. Snyder, 1927). Suffice it to say here that there are no changes in the blood group of an individual after etherization, Roentgen irradiation, the administration of drugs, or the course of a disease or its treatment; and there is no variation in groups due to age, sex, vocation, climate, or living conditions.

The third point, the absence of conscious selection in the case of the blood groups, is self-evident. Mates have not been chosen because of their blood groups. Any selective value possessed by the blood groups must be due to a secondary relation with some other factor which possesses a selective value of its own. Thus far no such relation has been demonstrated. The blood groups are inherited independently of all other hereditary human characters which have been available for study, and in addition the distribution of the groups is

normal among various pathologic, physiologic, and morphologic conditions.

The fourth point, involving the distribution of the blood groups among various races, is one of the most striking and best demonstrated. Starting with the work of the Hirszfelds in 1919, peoples in all parts of the world have been investigated. The Hirszfelds' original work, involving the blood group distribution among sixteen different nationalities, indicated that the variation in blood group proportions was roughly correlated with geographical distribution, and more specifically correlated with racial affinities. Subsequent studies on many peoples in all parts of the world have confirmed this view.

The fifth point involves the demonstration of the constancy of the groups from generation to generation in the absence of racial crossing. This has been demonstrated for various peoples and for varying periods of time. Perhaps the most outstanding is the case of the Gypsies, studied by Verzar and Weszeczky (1922). They found that Gypsies in Hungary, having lived there without intermarriage with the surrounding Hungarians for several hundred years, still showed the same blood group distribution as the present natives of India, from whom they were derived, quite different from the group distributions of the surrounding Hungarians.

The sixth and last point, involving the modification of the blood group proportions by racial crossing, was demonstrated by the present writer in 1926. It was shown that American Indians were mostly of group O, and that full-blooded Indians were probably all of group O. A graded series from full-blooded Indians to whites was presented, which showed a constant increase in the agglutinogens. Similarly, it was shown by the present writer in 1929 that Jamaicans, who have undergone considerable crossing with the whites, show blood group frequencies definitely nearer those of the whites than do the Yoruba, an unmixed tribe of southern Nigeria, the ancestral home of the Jamaicans.

BLOOD GROUP INDICES

Based on these six point, the anthropologic value of the blood groups would seem to be clearly established. Knowing the proportions of the four blood groups in any race, how shall we make specific use of the information? The first method, suggested by the Hirszfelds in 1919, was the biochemical index. I have several times pointed out the fact that the index is worthless. Other similar indices have been suggested, all of them in my opinion equally without value. The six indices thus far suggested are as follows:

(1) Biochemical race index (Hirszfeld and Hirszfeld) $= \frac{A + AB}{B + AB}$

(2) Serological group index (Leveringhaus) $= \frac{O + A}{O + B}$

(3) Biological race index (from Bernstein's formulae) $= \frac{p}{q}$

(4) Serological regression index (Wellisch) $= \frac{(A + AB)(O + B)}{(B + AB)(O + A)}$

(5) Serological race index (Lattes) $= \frac{A}{B}$

(6) New biochemical race index (Melkich) $= \frac{O + A}{B + AB}$

With the exception of index (6), the following general statements hold true:

When A = B, all indices = 1.
When A < B, all indices < 1.
When A > B, all indices > 1.

When various peoples are arranged in order according to one of the indices, they are also in order generally in regard to the others.

The frequencies p, q, and r, however, representing the frequency of the three allelomorphs A, B, and O, respectively, are of much more value than the frequencies of the groups as such. These frequencies may be calculated as follows:

$$p = 1 - \sqrt{O + B}$$
$$q = 1 - \sqrt{O + A}$$
$$r = \sqrt{O}$$

Plotting the frequencies p and q on a correlation table, and inserting each race in its proper square, we have a chart such as that shown in figure 1. It will be seen that the various peoples fall into more or less natural groups. The frequency r is ignored in this chart, since $p + q + r = 1$, and p and q represent the frequencies of the two dominant mutations. The fact that the grouping of races on the chart coincides so markedly with the grouping based on other and longer-known anthropologic criteria, coupled with the facts that there can be no question of conscious selection involved; that the blood groups are definitely hereditary; that they are stable both in the individual throughout life, and in the race in the absence of crossing; and that racial crossing exerts a powerful effect on blood group distribution; all

indicate forcibly the value of the blood groups as additional criteria of race-classification.

I have formulated four "laws" of serologic race-classification. They are presented as admittedly tentative, subject to modification and change, but with the firm belief that in the future no anthropologic study will be complete without a knowledge of the blood group proportions of the people under discussion. The laws are as follows:

q \ p	0-5	6-10	11-15	16-20	21-25	26-30	31-35
0-5	AMERICAN INDIANS (in whole)	AMERICAN INDIANS ESKIMOS			AUSTRALIANS		
6-10		FILIPINOS		ICELANDERS	DANES	AMERICANS ENGLISH FRENCH ITALIANS MALTANS GERMANS GERMAN JEWS AUSTRIANS DUTCH SERBS GREEKS LAPPS	NORWEGIANS SWEDES
11-15			SOUTH AFRICANS YORUBA MOROCCANS	AMERICAN NEGROES MADEGASCANS MELANESIANS RIFFIANS JAMAICANS	ARABS TURKS RUSSIANS SPANISH JEWS SLOVAKS	ROUMANIANS BULGARIANS POLISH JEWS FINNS	ARMENIANS LITHUANIANS
16-20			SENEGALESE SUMATRANS	ANNAMESE JAVANESE SUMATRAN CHINESE KATANGANS	SOUTH CHINESE	NORTH JAPANESE HUNGARIANS POLES	SOUTH JAPANESE MID. JAPANESE FORMOSANS ROUMANIAN JEWS
21-25				NORTH KOREANS ORokko	MID. KOREANS	EGYPTIANS	SOUTH UKRAINIANS UKRAINIANS
26-30			NATIVES OF INDIA GYPSIES	NORTH CHINESE MANCHUS		AINU	

FIG. 1.—Correlation of p and q among the races of the world.

(1) Any people whose blood group distribution is being studied may be expected to show blood group frequencies similar to those of other peoples known to be related to it.

(2) If any people shows blood group frequencies different from those to be expected based on the frequencies of other peoples known to be related to it, the conclusion may be drawn that the former has undergone racial crossing of some sort which the latter have not undergone, or vice versa.

(3) If any people shows blood group frequencies similar to a group of peoples not known to be related to it, the conclusion may be drawn that the former traces back to the latter somewhere in its ancestry, or else that the former has undergone crossing with the latter group or some similar people.

(4) If any people lacks one or both of the blood group mutations, as evidenced by an extremely low value of p or q, it may be assumed that that people became isolated from the rest of mankind before the respective mutations took place, or before they spread very far.

It is hoped that these laws will find approval among anthropologists, and will serve to crystallize opinion on the value of the blood groups as additional supplementary anthropologic criteria.

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NOTES

THE CORRELATION OF SUMS

It sometimes happens that, after having correlated one variable with a series of others, one wishes to find the correlation of the first variable with the sum of the other variables. What is the functional relation between these correlations? Is the correlation of the first variable with the sum some sort of average of the correlations with the different elements of the sum? And if so, what sort of average? These questions may easily be treated by analytical methods.

Let $X = X_1 \pm X_2 \pm \cdots \pm X_m$; $Y = Y_1 \pm Y_2 \pm \cdots \pm Y_n$.

$x, x_1, x_2, \ldots x_m$; $y, y_1, y_2, \ldots y_n$, the respective deviations from the arithmetic means.

$\sigma_x, \sigma_{x_1}, \sigma_{x_2}, \ldots \sigma_{x_m}$; $\sigma_y, \sigma_{y_1}, \sigma_{y_2}, \ldots \sigma_{y_n}$, the respective standard deviations, $r_{xy}, r_{x_1y_1}, r_{x_1y_2}, \ldots r_{x_1y_n}, r_{x_2y_1}, r_{x_2y_2}, \ldots r_{x_2y_n}, \ldots r_{x_my_1}, r_{x_my_2}, \ldots r_{x_my_n}$; $r_{x_1x_2}, \ldots r_{x_1x_m}, r_{x_2x_3}, \ldots r_{x_2x_m}, \ldots r_{x_{m-1}x_m}$; $r_{y_1y_2}, \ldots r_{y_1y_n}, r_{y_2y_3}, \ldots r_{y_2y_n}, \ldots r_{y_{n-1}y_n}$, the respective coefficients of correlation.

N the number in the population.

Then $r_{xy} = p_{xy}/\sigma_x\sigma_y$

Where $p_{xy} = \frac{1}{N}\sum(xy) = \frac{1}{N}\sum(x_1 \pm x_2 \pm \cdots \pm x_m)(y_1 \pm y_2 \pm \cdots \pm y_n) = \frac{1}{N}\sum(x_1y_1 \pm x_1y_2 \pm \cdots \pm x_1y_n \pm x_2y_1 \pm x_2y_2 \pm \cdots \pm x_2y_n \cdots \pm x_my_1 \pm x_my_2 \pm \cdots \pm x_my_n) = \sigma_{x_1}\sigma_{y_1}r_{x_1y_1} \pm \sigma_{x_1}\sigma_{y_2}r_{x_1y_2} \pm \cdots \pm \sigma_{x_1}\sigma_{y_n}r_{x_1y_n} \pm \sigma_{x_2}\sigma_{y_1}r_{x_2y_1} \pm \sigma_{x_2}\sigma_{y_2}r_{x_2y_2} \pm \cdots \pm \sigma_{x_2}\sigma_{y_n}r_{x_2y_n} \pm \cdots \pm \sigma_{x_m}\sigma_{y_1}r_{x_my_1} \pm \sigma_{x_m}\sigma_{y_2}r_{x_my_2} \pm \cdots \pm \sigma_{x_m}\sigma_{y_n}r_{x_my_n}$, and

$\sigma_x^2 = \frac{1}{N}\sum(x)^2 = \frac{1}{N}\sum(x_1 \pm x_2 \pm \cdots \pm x_m)^2 = \frac{1}{N}(x_1^2 + x_2^2 + \cdots + x_m^2 \pm 2x_1x_2 \pm \cdots \pm 2x_{x_1x_m} \pm 2x_2x_3 \pm \cdots \pm 2x_2x_m \pm \cdots 2x_{m-1}x_m) = \sigma_{x_1}^2 + \sigma_{x_2}^2 + \cdots + \sigma_{x_m}^2 \pm 2\sigma_{x_1}\sigma_{x_2}r_{x_1x_2} \pm \cdots \pm 2\sigma_{x_1}$

$\sigma_{x_m} r_{x_1 x_m} \pm 2\sigma_{x_2}\sigma_{x_3} r_{x_2 x_3} \pm \cdots \pm 2\sigma_{x_2}\sigma_{x_m} r_{x_2 x_m} \pm \cdots \pm 2\sigma_{x_{m-1}}\sigma_{x_m} r_{x_{m-1} x_m}$, the well known result for the standard deviation of a sum or difference in terms of the standard deviations and coefficients of correlation of its elements. The expression for σ_y is, of course, similar to that for σ_x. This result may be derived from Reed's[1] formula for the correlation of two functions. It has also been treated by Spearman.[2]

The correlation r_{xy} depends, therefore, not only on correlations of the form $r_{x_i y_j}$, but also on correlations of the forms $r_{x_i x_j}$ and $r_{y_i y_j}$. The result, paradoxical at first sight, follows that the correlation, r_{xy}, of the sums of elements may be larger than the correlations of the separate elements, $r_{x_i y_j}$. This will occur in cases where correlations of the forms $r_{x_i x_j}$ and $r_{y_i y_j}$, which enter only into the denominator of the expressions for r_{xy}, are negative. The example below will illustrate this. Here $X = X_1$, $Y = Y_1 + Y_2$, $\sigma_x = 1.118$, $\sigma_{y_1} = 5.000$, $\sigma_{y_2} = 5.590$, $r_{xy_1} = -0.4472$,

X	Y	Y_1	Y_2
1	10	10	0
2	11	0	11
3	12	10	2
4	13	0	13

$r_{xy_2} = 0.6000$, $r_{y_1 y_2} = -0.9838$. Substituting in the formulae, $\sigma_y^2 = (5.000)^2 + (5.590)^2 + 2(5.000)(5.590)(-0.9838) = 1.254$; $\sigma_y = 1.120$. By direct calculation $\sigma_y = 1.118$. $p_{xy} = (1.118)(5.000)(-0.4472) + (1.118)(5.590)(+0.6000) = 1.250$. By direct calculation $p_{xy} = 1.250$. $r_{xy} = 1.250/1.118 \times 1.120 = +0.9984$. By direct calculation $r_{xy} = +1$.

Thus we can see how, as a result of the negative value of $r_{y_1 y_2}$, r_{xy} is greater than r_{xy_1} or r_{xy_2}.

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An example of the application of these formulae may be found in the correlation[3] of white homicide rates of the various registration states with the percentages of various ethnic stocks in the populations of the states. Here

$X = X_1$ = white homicide rate, 1922,
Y = percentage of Slavic and Lettic stock in population,
Y_1 = percentage of Czech stock in population,
Y_2 = percentage of other North Slavic and Lettic stock in population,
Y_3 = percentage of South Slavic stock in population.
$Y = Y_1 + Y_2 + Y_3$.

$\sigma_x = 3.039$; $\sigma_{y_1} = 0.7934$; $\sigma_{y_2} = 3.419$; $\sigma_{y_3} = 0.4302$;

$r_{xy_1} = -0.1367$; $r_{xy_2} = -0.3895$; $r_{xy_3} = +0.1682$;

$r_{y_1y_2} = +0.1755$; $r_{y_1y_3} = +0.2921$; $r_{y_2y_3} = +0.2950$.

Substituting in the formulae,

$$\sigma_y^2 = (0.7934)^2 + (3.419)^2 + (0.4302)^2 + 2(0.7934)(3.419)(0.1755) + 2(0.7934)(0.4302)(0.2921) + 2(3.419)(0.4302)(0.2950) = 14.524; \quad \sigma_y = 3.811.$$

By direct calculation $\sigma_y = 3.818$.

$p_{xy} = (3.039)(0.7934)(-0.1367) + (3.039)(3.419)(-0.3895) + (3.039)(0.4302)(+0.1682) = -4.157$.

By direct calculation $p_{xy} = -4.143$.

$r_{xy} = -4.143/3.039 \times 3.811 = -0.358$.

By direct calculation $r_{xy} = -0.357$.

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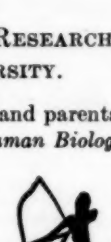

QUOTATIONS

COBBES QUESTIONS AND ANSWERS, 1614

Drolling prophecies were a rather popular form of ephemeral literature in the 17th century. To what extent their production was stimulated by way of imitation of the familiar *Pantagrueline Prognostication* of François Rabelais, it is impossible to say, but there is at least some probability that such was the case.

Cobbes Prophecies, which forms the subject of this note, is now a very rare pamphlet. It contains material under four heads: prophecies (in rhyme); madrigals, which are regarded by literary critics as forming the "salt of our curious tract"; the "Questions and Answers," here quoted in full; and finally "Cobs talke with Wisdome." The preface is signed by "Your well willer as to all honest Men, Richard Rablet." This is obviously a fictitious name. Mr. Bertram Dobell has suggested that the author called himself "Rablet" after Rabelais, which seems plausible. It was common practice at the time to sign these mock prognostications with assumed names. "Mr. Jocundary Merriebraines" is the stated author of *The Owles Almanacke*, 1618, for example, and "William Terilo" of *Friar Bakons Prophesie*, 1604.

Cobbes Prophecies was reproduced in facsimile by Charles Praetorius (with a preface by A. H. Bullen) in 1890, not published, but printed for private circulation. It is from a copy of this reproduction that the "Questions and Answers" are here printed in photographic facsimile, preceded by a similar reproduction of the title page. The economical and biting wit of many of the "Answers" give real insight into the modes of thought and outlook of men three hundred odd years ago. In a small way it makes a contribution to 17th century human behavior, of the same sort as the plays, and particularly the tracts of Thomas Dekker (ca. 1570–1641), the author of *The Honest Whore*, of whom it has been said that: "The social student cannot afford to overlook Dekker; there is no other dramatist of that age, except Thomas Middleton, from whom we can get such a vivid picture of contemporary manners in London."

COBBES PROPHECIES, HIS SIGNES AND TOKENS,

his Madrigalls, Queſtions, and An-*ſweres, with his ſpirituall Leſſon, in* Verſe, Rime, and Proſe.

Pleaſant, and not vnprofitable.

Reade that will, Iudge that can, Like that liſt.

Printed at London for *Robert Wilſon*, and are to be ſold at his Shop at Grayes-Inne Gate.
1614.

The madrigals are merry verses, a little broad in their language, but wholesome and healthy in their tone. The prophecies are constructed strictly on the orthodox pattern of the time; a long series of successive lines each postulating an absurd paradox, finally ending with a spoofing anticlimax which is no prophecy at all. For example:

. . . . . .

When rich wares will be at low rate,
And a Citty will runne out at the Gate:
The Sailor cannot away with a merry gale,
And the Constable is afraid of a pot of Ale.
When the Goose is mistaken for the Swan,
And the goodwife knowes not her good Man;
If the world were come to such a change,
The alteration would be very strange:
But rather then all should go so amisse,
Better be content with it, as it is.

The "then" in the line next to the last seems plainly a misprint for "than."

R. P.

Questions and Answers.

Qu. WHy ſhould a rich man become a Theefe?
An. Becauſe the ſweete of gaine ouercomes his (ſence.
Que. Why ſhould any man want Mony?
An. Becauſe ſome ſpend it faſter then they can get it.
Que. Why are old folkes in loue?
An. Becauſe eaſe breeds idleneſſe.
Que. Why is Tobacco in ſuch eſteeme?
An. Becauſe it dries vp Rheume, and ſpends drinke.
Que. Why do ſo many people vſe gaming?
An. Becauſe they want wit for better exerciſe
Que. Why is a Cuckold patient?
An. Becauſe of profit or feare.
Que. Why are men iealous of their wiues?
An. Becauſe they are Fooles.
Que. Why are offenders puniſht?
An. To keepe the Subiects in peace.
Que. Why are Gallants flattered?
An. For a Fooles pride, and a Knaues profit.
Que. Why do Children cry?
An. Becauſe they know not what they would haue.
Que. Why doe Beggars skold?
An. Becauſe they are commonly drunke.
Que. Why doe Apes counterfeit men?
An. Becauſe men counterfeit Apes.
Que. Why are Lawes ordained?
An. To giue euery man his right.
Qu. Why are their ſuch delaies in their execution?
An. Becauſe there are ſo many cauſes to diſpatch.
Que. What makes wares deere in the world?
An. The multitude of people,

Queſtions and Anſwers.

Qu. *And what makes cheapneſſe?*
An. Aboundance.
Qu. *Where is the beſt dwelling in the world?*
An. In a mans owne houſe.
Qu. *And where is the beſt being for all men?*
An. In Heauen.
Qu. *What is of moſt eſteeme in the world?*
An. Mony.
Qu. *What is the leaſt cared for of a great many?*
An. Conſcience.
Qu. *Why is honeſty with many held a Ieſt?*
A. Becauſe there are ſo few honeſt in earneſt.
Qu. *Which is the beſt ground to plant on?*
An. That which is a mans owne.
Qu. *Why ſhould Beggars liue without labour?*
An. Becauſe their Mony comes in eaſily.
Qu. *Why do Gamſters fall out ſo oft?*
An. Becauſe loſſe breeds impatience.
Qu. *Why are rich men moſt ſickly?*
An. Becauſe they take to much eaſe.
Qu. *What is the beſt Phiſicke for all Natures?*
An. Motion.
Qu. *When is beſt taking Phiſicke?*
An. When one is ſicke.
Qu. *What ſickneſſe is moſt dangerous?*
An. The Plague.
Qu. *What moſt vnſightly?*
An. The Poxe.
Qu. *What moſt continuing?*
An. The Ague.
Qu. *What moſt incurable?*

An.

Queſtions and Anſwers.

An. The Gout.
Qu. *What moſt painefull?*
An. The Tooth-ach.
Qu. *What moſt common?*
An. The Rheume.
Qu. *What is ill for the eye-ſight?*
An. An Enemy.
Qu. *What is good for it?*
An. Gold.
Qu. *What is the fruit of Learning?*
An. Pride, pleaſure, or profit.
Qu. *What is the honor of the Law?*
An. Iuſtice.
Qu. *What is the Glory of the Law?*
An. Mercy.
Qu. *And what is the force of the Law?*
An. Obedience.
Qu. *VVhat makes Lawyers rich?*
An. Contentions of Clients.
Qu. *What makes Magiſtrates honorable?*
An. Execution of Iuſtice.
Qu. *What is the poore mans happineſſe?*
An. Patience.
Qu. *And what is the wiſe mans wealth*
An. Content.
Qu. *VVhy are faire women moſt loued?*
An. Becauſe mens eies marre their wits.
Qu. *VVhy do wiſe men keepe Fooles?*
An. To exerciſe their Charity.
Qu. *VVhy are Diuines moſt worthy Reuerence?*
An. Becauſe they are the mouths of God vnto his (people.
Qu. *VVhy are ſo many Sects in Religion?*

Questions and Answers.

An. Becauſe the Deuil ſowes ſedition in the Church.
Que. Why do many befoole themſelues with Idolatry?
A. Becauſe blindnes in deuotiō breeds indiſcretion.
Que. Why ſhould wiſe men be vndone by ſuretiſhip?
An. Becauſe their loue exceeds their wits.
Qu. Why are men vndone by women?
An. Becauſe they had rather be ſlaues then free-men.
Que. Why do many Louers grow franticke?
An. Becauſe they ſeek that which is hard to be found.
Que. Why do mad men talke ſo much?
A. Becauſe their tongues wag with the wind of their braine.
Que. Why are honeſt harts moſt croſſed?
An. To try their patienee.
Qu. When are the patient moſt happy?
An. At the houre of Death:
Que. What is the greateſt feare in the world?
An. To dye.
Que. What is the greateſt greeſe?
An. Want.
Que. Why do Phiſitions die?
An. Becauſe Death is to cunning for them.
Que. Why doe men cry out vpon Fortune?
An. To excuſe their follies.
Que. Why do Labourers ſing?
An. For the hope of their wages.
Que. Why do wiſe men take thought?
An. Becauſe their wits are oppreſſed.
Que. Why are fooles full of Mony?
An. Becauſe tis their baby to play withall.
Que. Why do Miſers build faire houſes?
An. To mocke Beggars.
Que. Why doe Beggars loue their drinking?

An.

Cobs talke with Wisedome.

An. Becauſe it is an exerciſe of Idleneſſe.
Que. Why do Scolds loue ſcolding?
An. Becauſe it is their naturall Muſique.
Que. Why do not Theeues feare hanging?
An. Becauſe it is ſo eaſie a puniſhment.
Que. Why doe not the wicked feare God?
An. Becauſe they are to great with the Deuill.
Que. Why are the vertuous moſt happy.
An. Becauſe their ioyes are in heauen.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

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